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TABLE OF CONTENTS

Page

LEADING ARTICLES:

The Proposed New Railway Lines for the Development of the Port of Genoa, Italy (illustrated). Charles R. King..... 273
Specifications for Bessemer Steel Rails..... 275
A Cast-Iron Meter Box (illustrated). Edward H. Cowan..... 275
Improvement of a Plate Girder Bridge at Hartford, Conn. (illustrated). Henry Robinson Buck..... 276
Report to the Chief of Engineers, U. S. A., on the Baltimore Fire. Capt. John Stephen Sewell..... 276
President Roosevelt's Instructions to the Isthmian Canal Commission..... 279
The Calculation of Sinking Funds. Peter Mogensen..... 284
The Relation Between Unfiltered Water and Typhoid Fever at Lorain, O. (illustrated). C. Arthur Brown..... 285
Annual Convention of the American Railway Engineering and Maintenance of Way Association..... 285
Report on Proposed High Pressure Fire Service for Borough of Manhattan, New York City (illustrated). Nicholas Hill, M. Am. Soc. M. E..... 287
Report on Proposed High Pressure Fire Service for Borough of Brooklyn, New York City (illustrated). I. M. De Varona, M. Am. Soc. C. E..... 288
Track Inspection Car on the Northern Ry. of France (illustrated)..... 290

Page

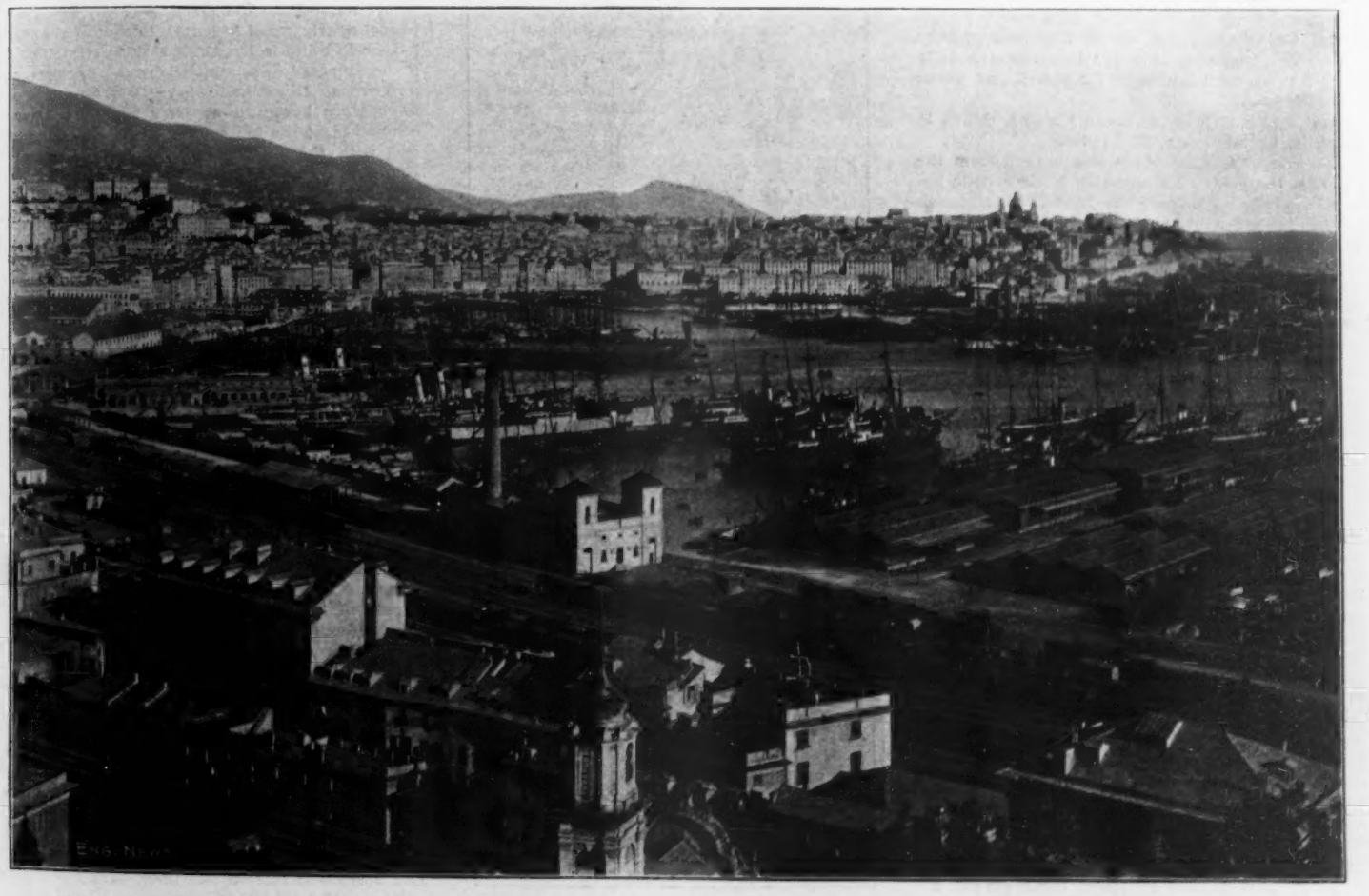
A New Design of Truss with Pin and Riveted Connections (illustrated)..... 291
The Planning of Factory Buildings and the Influence of Design on Their Productive Capacity. Hugo Diemer..... 293
Stock Distribution and Its Relation to the Life of a Blast-Furnace Lining (illustrated). David Baker, M. Am. Inst. Min. E..... 294
ENGINEERING NEWS OF THE WEEK..... 279
EDITORIAL COMMENT.—Concerning the Responsibility for Safe Building Construction and Where It Should be Placed——The Pan-American Intercontinental Railway Scheme——Railway Development in South America——The Convention of the Railway Engineering Association..... 280
EDITORIAL.—Concerning the Fall of the Darlington Building..... 281
LETTERS TO THE EDITOR.—Slow Decompression Is the Best Way to Prevent "The Bends": James P. Nelson——Some Remarkable Records in Taking Soundings Through Ice on Lake Superior: G. A. Taylor——Log. Functions of Small Angles and Constructing a Parabola (illustrated): E. B. Escott——The Work of the Corps of Engineers: "Commerce"——A Neat Detail for Hydraulic Elevator Plungers (illustrated): Edward Van Winkle——Determining Superelevation on Curves: John P. Brooks; Wm. P. Watson, M. Am. Soc. C. E.; W. D. Taylor——Effect of the Baltimore Fire on the Continental Trust Building: J. G. Glaven——The Penalty Clause in Engineering Contracts: W. A. Stevenson——Notes and Queries..... 282-284

THE PROPOSED NEW RAILWAY LINES FOR THE DEVELOPMENT OF THE PORT OF GENOA, ITALY.

By Charles R. King.*

The commercial development of the port of Genoa, Italy, is at present attracting the attention of the most able and influential engineers of Genoa and the interior of Italy. At present there are two lines of railway traversing this range of mountains, but they both have very steep grades and numerous curves. Two other railway lines have been projected to overcome these obstacles to traffic, and it is likely that contract tenders will soon be asked for constructing one of these lines.

The oldest of the two existing lines, which passes via Giovi and by the celebrated tunnel of that name, was constructed in 1853, and at that time was considered, as it indeed remains to this day, a monumental work in the annals of railway engineering. Starting with an altitude of 53 ft. at Genoa (Principe Station) it rises to an



VIEW OF GENOA, ITALY, LOOKING TOWARD SPEZIA: THE COAST TERMINUS OF THE PROJECTED TRANS-APENNINE RAILWAYS.

Italy. The object in view is not only to increase the capacity of the harbor for shipping, but also to provide easier and, therefore, cheaper transit from the city inland. As is well known, the Ligurian Apennines offer a physical barrier between Both of these new lines have much easier grades and curves than the older lines.

EXISTING LINES.—To give an idea of the country traversed by these existing and projecting railways, a brief description of the two existing lines is necessary.

elevation of 1,263 ft. above sea level at the summit of the incline near Busalla station, distant 14¼ miles from Genoa, but only 6.6 miles from the base of the steep incline. The total length of this double-track mountain line from Genoa to Novi is 33¼ miles, and the maximum grade of 1 in 28

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occurs in the Polcevera valley on a stretch 1.3 miles in length between Pontedecimo and Montanesi. The railway then enters (at the twelfth mile) the two-mile tunnel of Giovi, but at a lesser inclination, varying between 1 in 33 and 1 in 34.5, and emerges thence by the higher portal in the Scrivia valley, about a quarter mile below Busalla station, from which point the line falls to Ronco and to Novi.

There are ten other tunnels along this line from Genoa to Novi, four north of the Apennines, with lengths of from 507 to 866 meters, and six to the south varying from 36 to 686 meters in length. The whole of the tunnels aggregate 4½ miles. The minimum curves on this line are of 1,300 ft. radius, excepting a curve of 970 ft. radius at Isola del Cantone station, and another of 585 ft. at Genoa station. The hilly section is laid with double-headed rails of 73 lbs. per yd, held in chairs, and those in the tunnels weigh 84 lbs. per yd. The normal Italian main-line flanged rail weighs 73 lbs. per yd.

The train loads passing by this route are relatively light, the maximum weight being 280 tons, composed of fifteen 18-ton goods cars, with brake van. The locomotives mostly employed are an old but highly prized type of eight-coupled goods engines, with tenders, built by Sigl, of Vienna, between the years 1873 and 1877, and weighing loaded 79 tons. Three such engines, each one with a tractive effort of 15,000 lbs. at a speed of 12 miles per hour, are used for hauling the heaviest freight loads, while for international express trains of from 140 to 200 tons net, one six-coupled express engine of about 82 tons weight and one goods locomotive are employed, the latter pushing uncoupled behind.

The speed of goods trains averages 12 miles per hour, although on the greatest inclination of the line it drops to little more than walking pace. Local trains are made up of five four-wheeled cars. The traffic on this line is suspended daily from 9 p. m. until 1.40 a. m. for tunnel and works inspection.

The total length of the mountain line, Genoa to Novi, is, by this route, 33.3 miles.

The second existing route is a branch from the old line, the point of bifurcation being a little below Rivarolo, 3.3 miles from Genoa. This branch rejoins the older line at the summit at Ronco station. It is known as the "Succursale" of Ronco, and was opened to traffic in June, 1889. The whole of the railway works, viaducts and permanent way, are constructed with remarkable solidity, and are capable of bearing almost any future increases in the train loads. The numerous handsome brick viaducts which bridge the gorges between rocky spurs pierced by the tunnels are all of admirable and imposing appearance, particularly as seen from the lower main line of Giovi. The incline commences near the Sampierdarena goods sidings, and is continuous to Ronco station, 17.2 miles from Genoa. Ronco is the culminating point of the mountain railway, the altitude being 1,053 ft., while the total rise from Sampierdarena is 308 meters, or 1,001 ft, in a distance of 24 kilometers, or 15 miles. The maximum rate of inclination is 1 in 62 on the open line, and 1 in 85 in the Ronco tunnel, but is reduced in the stations of San Quirico and Mignanego to 1 in 500. The minimum radius of the curves is 1,300 ft. in the open and 1,625 ft. in the tunnels. The road is double-track, laid with rails of double-head section, 81 lbs. to the yard in the open and of 96 lbs. in the long tunnel, all secured in cast-iron chairs. The granite ballasting is excellent, and the sleepers, which are uncovered between the rails, are well banked at their extremities. The block system of signaling is in operation here as on all the main lines in the northern half of Italy.

The Ronco tunnel at the top of the hill is the second longest tunnel in Italy, coming next to the Mont Cenis. It is a little over 5 miles in length, and is very remarkable for its special system of forced ventilation. At its lower extremity (Mignanego) the branch line and the older line of Giovi both rise to an equal elevation on the mountain side, their different gradients at this spot presenting a striking contrast. The remainder of the short tunnels south of the sub-Apennine passage aggregate 4,543 m. in length. There are on the whole of the line from Genoa to Novi 9½ miles of tunnel.

By this route the distance from Genoa to Novi is about the same as by the older line, that is, close upon 33 miles. From the Ronco summits towards Novi (altitude 640 ft.) the Torino line falls at a maximum rate of 1 in 122, and its minimum curves through the Scrivia valley are of 2,000 ft. radius. By the branch from Novi to Tortona, for Milan, Switzerland, etc., the line drops to 380 ft. altitude. The distance from Genoa to Tortona is 44.3 miles. The traffic on this line is stopped daily between 1 and 5 o'clock for tunnel and line inspection.

Maps Showing Routes of Existing and Projected Trans-Apennine Railways in Italy.

MEDITERRANEAN CO.'S PROJECT.—Of the new projects to meet the extraordinary augmentation in traffic from Genoa, the first is by the Mediterranean Co. for an entirely new and independent double-track line, constructed with easy grades, across the Apennine chain to Novi via Voltaggio and Gavi, and would comprise in its length two horseshoe curves in the Secca valley, two helical tunnels below Isoverde, and a straight tunnel of 6¼ miles length between the latter place and Voltaggio, which last is the highest point attained, viz., 313 m., or 1,020 ft., altitude above sea level. The total length of this line, Genoa to Novi, is 58¼ kilometers (36.3 miles), or 3.3 miles more than by the present route; but this distance is thus developed artificially, by means of the loops and the helical tunnels mentioned, in order to diminish the rate of inclination to a maximum of only 1 in 111 in the open, and 1 in 130 in the long tunnel, upon the 25½ miles intervening between the base of the incline and its summit at Voltaggio. Proportionate reductions are also made in the gradients of other tunnels in relation to those which prevail outside. In this project there is an aggregate of 15.1 miles of curves, which abound in the lower sections, while 21.2 miles are straight line. The radius of the curves range from 6,400 ft. to 3,250 ft. Of the shorter tunnels there are 25, one-half of which have lengths of under 4,875 ft., while the remainder vary between 1,625 ft. and 3,250 ft. in length.

GENOA MUNICIPAL PROJECT.—The second or Genoa municipal project is for a more direct double-track route reaching the Milan main line at Tortona, without deviation, via Rigoroso and Villavernia. The distance to Tortona by this line would be only 57.6 kilometers, or 36 miles. The highest elevation reached would be at Rigoroso (230 m., or 747 ft.) attained by means of easy grades, which would have a maximum of only 1 in 118 in the open and 1 in 144 in tunnel. This line would necessitate the piercing of a long straight tunnel nearly equal in length to that of the Simplon, or 12 miles in length, if a short stretch of 300 ft. be excepted at a point where the line crosses a gorge near Ricco and where it is also proposed to locate a bye station. This long tunnel would commence at the tenth kilometer from Genoa and end with the thirtieth in the Scrivia valley at Rigoroso. The line would, in its course, be connected with the large sorting goods siding now being laid out at the Parco di Campasso, for the relief of the port sidings, and later on would twice pass below the present Genoa-Novi line: once near Mignanego and then further north at Rigoroso. From the latter point the line falls continuously to Tortona, with a maximum inclination of 1 in 227. This projected line would be connected at the 21st mile by a short branch to the older Novi line just south of Serravalle, shortening the distance from Genoa to Novi to 44½ kilometers, or 27.6 miles. This convenient junction with the Alessandria line would connect Genoa with Mont Cenis via Torino; with the Simplon via Novara; with the Gotthard via Novara and Luino, while the latter Swiss line would, in addition, be reached direct by the new main line from Genoa via Tortona and Milan.

As an offset to the cost of boring such a long tunnel as the one proposed there would be a first saving effected in avoiding the erection of numerous viaducts and bridges across the lateral valleys south of the Apennines. The aggregate length of tunnels is 23,850 meters, of which 24,700 meters (13½ miles) are between Rivarolo and Rigoroso, and 2,150 meters are between Genoa (Porta Principe Station) and Campasso.

In the length of 37½ kilometers (23.3 miles) from Genoa to the old line at Serravalle, 27.7 kilometers would be straight and only 9.8 kilometers curved line, the latter nearly all in the open and subdivided as follows: 960 meters Genoa to Campasso sidings and 8.9 kilometers between Rigoroso and Serravalle station (old line). Their minimum radii would be 2,440 ft.

A comparison of the length of two existing lines with the two alternative lines proposed appears as follows, the virtual distances being estimated by Lindner's formula, wherein the direct measure of length plus the vertical distances comprises also the resistance due to curves on levels and on up grades:

	In meters, via			
	Giovi.	Ronco.	Voltaggio.	Rigoroso
Real distances	52,504	52,770	58,255	44,658
Virtual distances..	153,912	140,218	149,508	130,000
Length of tunnels.	7,381	15,494	32,716	22,220
Percent	14	29	56	50
Max. altitudes ...	361.19	324.14	313.40	230.0
Max. gradients* ..	35.0	16.0	9.0	8.45

*Per 1,000.

From the above it is seen that the curves which augment the real distance by the Voltaggio route also contribute a little to the vertual distance in spite of the gain realized in the decreased maximum altitude as compared with the Ronco line.

The virtual distances in the return from Novi to Genoa are as follows:

	Meters.		Meters.
Via Giovi.....	96,344	Via Voltaggio.....	60,063
" Ronco.....	78,381	" Rigoroso.....	27,501

In the above the advantage of the lowered attitude effected by the Voltaggio project, as compared with the Ronco line, is more evident, the curves on the up-gradient in this case being less.

The Rigoroso route to Novi shows a less gain in the matter of real distance than it does when Tortona on the Milano line is considered as the objective point, as will be seen from the following:

Real Distances, Genoa to Tortona.

Via Ronco	71,110 meters.
" Voltaggio	76,595 "
" Rigoroso	57,600 "

the saving via Rigoroso, as compared with Ronco, being 8.3 miles.

The permanent way and constructional works for either of the projects named would be of the most modern description and intended for high speed traffic.

The Municipality of Genoa recently invited a commission of experts to report upon the two projected lines. This commission was composed of M. H. Dietler, Director of the St. Gotthard Railway; Signore G. Colombo and P. Tortarola, and the technical considerations elucidated by their report appear much in favor of the Rigoroso route, despite the great length of its tunnel. This result is important when it is remembered that the eminent professor of engineering at Milano, Senator Colombo, was one of the three members of that Commission of Italian, English and Austrian engineers which decided the Italian Government in favor of the route finally adopted for the Simplon tunnel, now approaching completion.

Numerous plans have been put forward for working the chosen route by water power with electric transmission of the force so developed.

SPECIFICATIONS FOR BESSEMER STEEL RAILS.*

(1) (A) The entire process of manufacture and testing shall be in accordance with the best curent practice, and special care shall be taken to conform to the following instructions:

(B) Ingots shall be kept in a vertical position in the pit heating furnaces until ready to be rolled, or until the metal in the interior has time to solidify.

(C) No bled ingots shall be used.

(D) Sufficient material shall be discarded from the top of ingot to insure sound rails.

(2) Rails of the various weights per yard specified below shall conform to the following limits in chemical composition:

	50 to 59 lbs. Per cent.	60 to 69 lbs. Per cent.	70. to 79 lbs. Per cent.	80 to 89 lbs. Per cent.	90 to 100 lbs. Per cent.
Carbon	0.35-0.45	0.38-0.48	0.40-0.50	0.43-0.53	0.45-0.55
Phosphorus, shall not exceed	0.10	0.10	0.10	0.10	0.10
Silicon, shall not exceed	0.20	0.20	0.20	0.20	0.20
Manganese	0.70-1.00	0.70-1.00	0.75-1.05	0.80-1.10	0.80-1.10

(3) One drop test shall be made on a piece of rail not less than 4 ft. and not more than 6 ft. long, selected from each blow of steel. The test piece shall, preferably, be taken from the top of the ingot. The rail shall be placed head upwards on the supports, and the various sections shall be subjected to the following tests under a free falling weight:

	Weight of rail, lbs. per yd.			Height of drop, ft.
More than	45	to and including	55	15
More than	55	"	65	16
More than	65	"	75	18
More than	75	"	85	20
More than	85	"	100	22

If any rail break when subject to the drop test, two additional tests will be made of other rails from the same blow of steel, and if either of these latter tests fail, all the rails of the blow which they represent will be rejected, but if both of these additional test pieces meet the requirements, all the rails of the blow which they represent will be accepted.

(4) The number of passes and speed of train shall be so regulated that on leaving the rolls at the final pass the temperature of the rail will not exceed that which requires a shrinkage allowance at the hot saws of 6 ins. for 85-lb. and 6⅛ ins. for 100-lb. rails, and no artificial means of cooling the rails shall be used between the finishing pass and the hot saws. The above shrinkage allowance may be varied, if necessary, so as to give a finishing temperature not exceeding 1000° F. at finishing rolls for mills rolling from reheated blooms, and not exceeding 1750° F. at finishing rolls for mills rolling direct from the bloom to the finished rail.

(5) The drop testing machine shall have a tup of 2,000 lbs. weight, the striking face of which shall have a radius of not more than 5 ins., and the test rail shall be placed head upwards on solid supports 3 ft. apart. The anvil block shall weigh at least 20,000 lbs., and the supports shall be part of, or firmly secured to, the anvil. The report of the drop test shall state the atmospheric temperature at the time the test was made.

(6) The manufacturer shall furnish the inspector, daily, with carbon determinations for each blow, and a complete chemical analysis every twenty-four hours, representing the average of the other elements contained in the steel, for each day and night turn. These analyses shall be made on drillings taken from small test ingot.

(7) Unless otherwise specified, the section of rail shall be the American standard, recommended by the American Society of Civil Engineers, and shall conform, as accurately as possible, to the templet furnished by the railway company, consistent with paragraph No. 8, relative to specified weight. A variation in height of 1-64-in. less, 1-32-in. greater than the specified height, and 1-16-in. in width will be permitted. The section of rail shall conform perfectly to the fishing dimension.

(8) The weight of the rails will be maintained as nearly as possible, after complying with paragraph No. 7, to that specified in contract. A variation of 0.5% for an entire order will be allowed. Rails shall be accepted and paid for according to actual weights.

(9) The standard length of rails shall be 33 ft.; 10% of the entire order will be accepted in shorter lengths, varying by even feet to 27 ft. A variation of ¼-in. in length from that specified will be allowed. All rails less than 33 ft. in length shall be painted green on the ends.

(10) Circular holes for splice bars shall be drilled in accordance with the specifications of the purchaser. The holes shall accurately conform to the drawing and dimensions furnished in every respect, and must be free from burrs.

(11) Rails shall be straight when finished, the traightening being done while cold, smooth on head, sawed square at ends, variation to be not over 1-32-in., and prior to shipment shall have the burr occasioned by the saw cutting removed and the ends made clean. No. 1 rails shall be free from injurious defects and flaws of all kinds.

(12) The name of the maker, the weight of rail and the month and year of manufacture shall be rolled in raised letters on the side of the web, and the number of blow shall be plainly stamped on each rail in at least two places not subsequently covered by the splice bars.

(13) The inspector representing the purchaser shall have free entry to the works of the manufacturer at all times when the contract is being filled, and shall have all reasonable facilities afforded him by the manufacturer to satisfy him that the finished material is furnished in accordance with the terms of these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment.

(14) No. 2 rails will be accepted up to 5% of the whole order. Rails that possess any injurious defects, or which for any other cause are not suitable for first quality, or No. 1 rails, shall be considered as No. 2 rails; provided, however, that rails which contain any physical defects which impair their strength shall be rejected. The ends of all No. 2 rails shall be painted in order to distinguish them. Rails rejected under the drop test will not be accepted as No. 2 rails. All No. 2 rails shall be painted white on the ends.

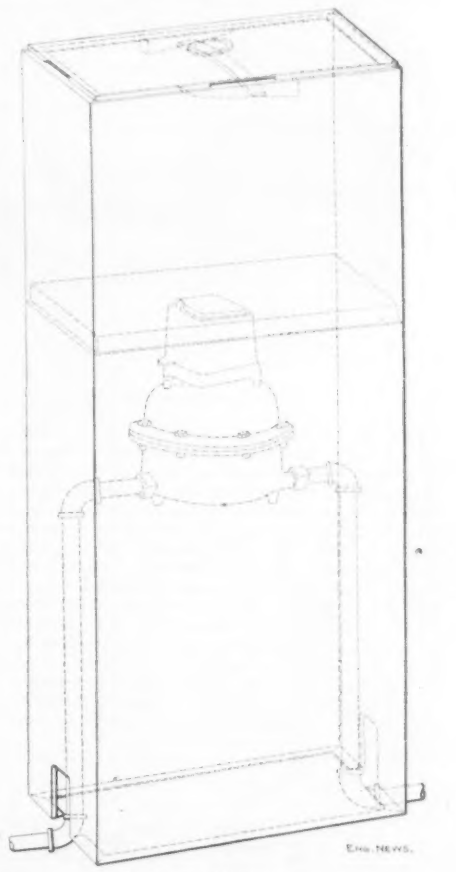
*Adopted by the American Railway Engineering and Maintenance of Way Association at its annual meeting at Chicago March 16.

A CAST-IRON METER BOX.

By Edward H. Cowan.*

The accompanying cut shows what might be called a transparent perspective view of a meter box, on which Mr. B. C. Palmer and the writer have recently secured a patent. It is made of cast iron and entirely independent of the meter and pipes.† In setting the box the meter is first connected and then the box is set down over it, the bottom being open except for a narrow flange around the outside. This open bottom allows any water which may come in from the top to drain away into the ground, and no trouble need be expected from water standing in the box above the top of the meter, as ground water will seldom stand so near the surface in any locality where there is city water.

About 10 ins. from the top a narrow flange is cast on the inside of the box, on which rests the lower cover, which is made of wood and covered



Cast-Iron Meter Box.

on the under side with felt. This lower cover, with the top cover, forms an air space, which is known from experience to absolutely insure protection from frost.

There is a flange around the top, similar to the one around the bottom, on the under side of which are cast two wedges with their points facing in opposite directions. In the center of the cover is a socket, with a hole passing through it, which contains a pentagonal headed bolt. The shank of the bolt, where it passes through the cover, is round, and below that it is made square, where it passes through a square hole in the bar. By turning the bolt (and bar) through a quarter circle the ends of the bar are made to come into contact with the wedges and hold the cover on firmly.

This cover arrangement is one of the most satisfactory features of the box. It is easy to open and shut, there are no threads to get filled with dirt, and the cover is held firmly even if small particles of dirt or stone get under its edge.

For convenience in casting, the box proper is made in two halves, which are joined together at diagonally opposite vertical edges by means of lugs cast on the inside of the box.

Ten of these boxes have been in service in this city since last spring, and they have given perfect satisfaction.

*Superintendent Marion City Water Co., Marion, O.

†A meter box of vitrified pipe, with a cast-iron cover and a sub-cover of wood and felt, to prevent freezing, was illustrated on p. 373 of our issue of Oct. 22, 1903, in an article on "The Methods and Cost of Installing Meters at Cleveland, O." The Cleveland water-works officials credit the design used by them to the water department of Watertown, Mass.—Ed.

IMPROVEMENT OF A PLATE GIRDER BRIDGE AT HARTFORD, CONN.*

By Henry Robinson Buck.†

The New York, New Haven & Hartford R. R. some time ago completed alterations to a bridge in Hartford which are of a rather unusual nature. Since the changes are such as might be made in any bridge similarly located, and as the results have amply justified the outlay, the matter may be of interest to others.

The bridge (Fig. 1) carries the four main tracks of the Hartford and Highland divisions over Asylum St., just south of the Union Station. It consists of four plate girders 7 ft. 9 ins. deep and 77½ ft. extreme length, forming two through bridges with a clear span of 70 ft. The crossing is skewed, with the tracks on a curve, so that the bridges are not parallel, and there is an open space of from 12 to 15 ft. between them. The floor system in each consists of beams about 2 ft. deep spaced 7 ft. apart, carrying stringers 14 ins. deep on which rest the ties. To prevent dripping onto the street, corrugated iron arches were sprung between the lower flanges of the stringers, and tar concrete deposited over them to a depth of some 5 ins. above the center of each arch. A gutter was formed at one side of the arch next to each stringer, with holes cut through the webs of the transverse floor beams to allow the water to flow through from the center to each end of the bridge. The gutters had a fall of ¼-in. to each floor beam, amounting to a grade of about 0.3%. The whole system was given a thick coat of asphalt, and for a time it made a water-tight and satisfactory floor.

FIG. 1. PLATE GIRDER BRIDGE BEFORE IMPROVEMENT.

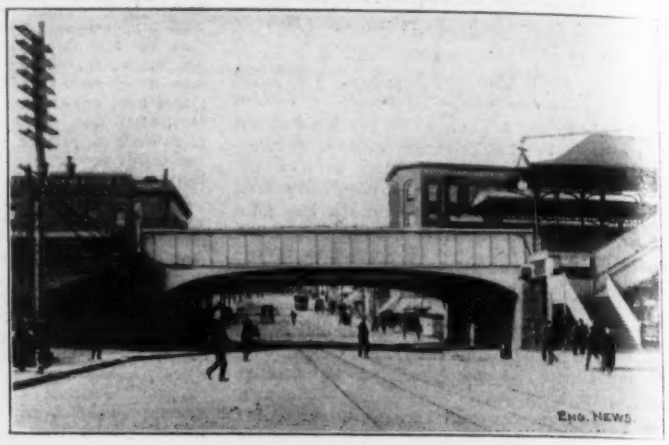


FIG. 2. PLATE GIRDER BRIDGE WITH ARCHED PANELS ADDED.

The bridge is now, however, over 13 years old, and for a long time past there have been abundant signs that the waterproofing was going to pieces. Greasy water dripped on the sidewalks below for a long time after every storm, showing that the water was being ponded by the floor beams, and instead of running rapidly to the scuppers at the ends of the bridge, was slowly filtering through the now defective asphalt. The bridge was boarded over just below the rail heads with matched pine boards, but there was no grade to this flooring, and from the nature of the case it could never be tight.

Several plans were recommended for remedying the nuisance, and early in 1902 the railroad company put up one of the usual wooden fans over one sidewalk, the slope being away from the abutment so that the water would drip into the street beyond the curb line. This would have cured the difficulty, but the roof was so extremely unsightly that great objection was made to it, and it was at once taken down. Plans were then drawn for a corrugated iron arch to span the whole street. It was to be hung from the floor beams and covered with asphalt, in order to shed the water into troughs next to the abutments. This was not built, however, as the record of the waterproofing in the original bridge seemed to show that its life would have been short. It would also have been quite expensive.

The method finally adopted was originated and designed by Mr. Frederick L. Ford, City Engineer. He proposed wooden fans, similar to the usual type, but sloping toward the abutments, and masked by galvanized iron brackets at each end. These brackets, the use of which are possible only when the fans are sloped opposite to the usual way, give this improvement its distinguishing character. Far from disfiguring the original structure, their curved lines add a touch of grace seldom seen in a plate girder. (See Fig. 2.)

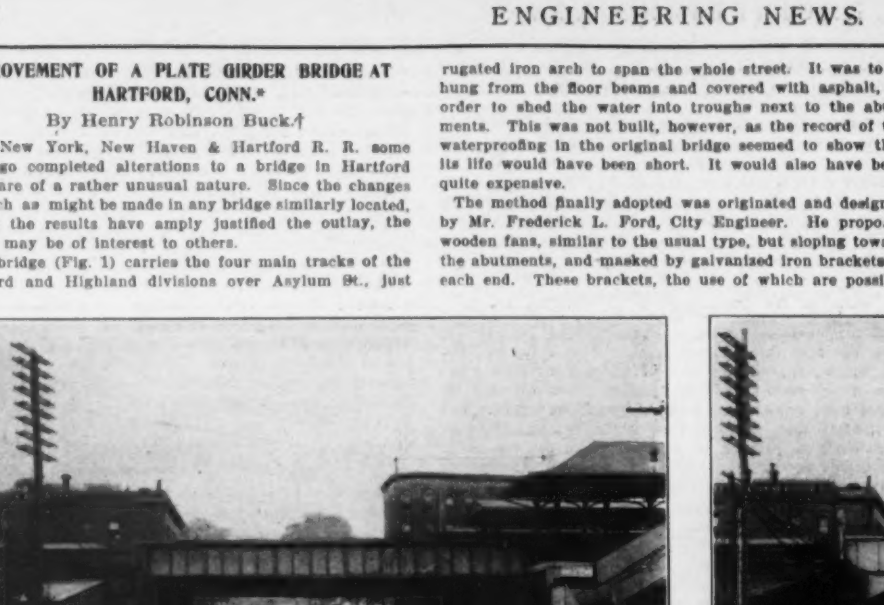

7/8" Boarding, Sloping to form Gutter
7/8" Matched Y.P. Flooring sheated with 16 oz. Copper.
5'0"
4"x6"
2'10"
2'10"
2'10"
2'10"
2'10"
14'7"
3'6"
4"x6" Y.P. Stringer
7/8" Sprung Moulding
C.I. Conductor Pipe with 6" Tile Connection to Street Sewer
Galv. Iron Panel
Hangers to be 1 1/4" x 1/2" Steel Straps Bent over Bottom Flange of Bridge
1" Bolts
22 Gage Galv. Iron
Bottom of Bracket turned under to be 3" wide
First Quality Southern Pine Lumber Stringers Planed all over.
Ceiling Boards 3 1/2" wide, Matched and Beaded
All Panels except at Ends 10'7"x2'10" c. to c.
10'7"
Incandescent Light with Reflector in Center of each Middle Panel, Over each Sidewalk
2'10"
ENG. NEWS.

FIG. 3. DETAILS OF DRIP APRON OR FAN FOR PLATE GIRDER BRIDGE.

The fans (Fig. 3) are suspended by wrought-iron clips from the bottom flanges of the floor beams. They are framed of 3-in × 6-in. southern pine joists which form panels 10 ft. 7 ins. × 2 ft. 10 ins. center to center, with ⅞-in. sprung molding around the sides of each panel. The sheathing is of first quality southern pine ceiling boards, matched and beaded, and along the outer edge of the roof (that is, over and parallel to the street curb) is a panelled edging 6 ins. high. All exposed surfaces are heavily varnished, and the general appearance of the whole is quite handsome. In the center of each middle panel, forming a row over each sidewalk, is an incandescent light with porcelain reflector, which will effectually light up a now dark place under the bridges.

To insure the permanent tightness of the roofs their upper surfaces are sheathed with 16-oz. sheet copper. Gutters are formed on each by inclined boards which fit against the top of the abutments, over which the copper is laid, conducting the water through two scuppers in each roof to drains laid to the street sewer. Both fans are continuous from side to side of the bridges, thus forming a roof over the space between them.

Directly under this formerly open space is an exit from the depot, and the new construction thus makes the bridge practically a sheltered extension of the train platforms, so that passengers can now take the trolley cars without having to go out from under cover.

After the fans were up the old concrete was completely removed, thus taking off about 40 tons of dead load from the bridges and affording a much needed opportunity for inspecting and painting the iron work of the floor system.

Excessive drip over the roadway is prevented by a pine sheathing, laid close up under the rail heads at the center of the bridge and sloping down to the base of the rail over each fan, upon which the water is allowed through slots. No special precautions were taken to make this part of the work water-tight, beyond a thorough painting, as it was not thought essential to entirely prevent drip over the roadway.

The four brackets which mask the ends of the roofs were designed to look like sections of arches supporting the main girders. They seem to the eye to strengthen the whole bridge, and are extremely pleasing, by reason perhaps of their apparent usefulness. The fan on the north side of the street is 14 ft. 6 ins. wide while that on the south side is only 9 ft., but this inequality is not noticed, as the brackets were of course made symmetrical, running out in each case 19 ft. 6 ins. They are built of 22-gage galvanized iron soldered up into panels, the ribs of which correspond with the stiffeners of the girder above. They are hung by inconspicuous clips from the bottom flange of the main girders.

The total cost of the improvements was about $3,000, which is much less than any efficient asphalt waterproofing would have cost.

The suggestion is offered that now highway bridges might well be fitted with drip fans arranged like the ones described, and masked by similar brackets.

Web girders never look beautiful, but these brackets make them decidedly less ugly at little or no additional cost.

*A paper read before the Connecticut Society of Civil Engineers.

†Assistant City Engineer, Hartford, Conn.

REPORT TO THE CHIEF OF ENGINEERS, U. S. A., ON THE BALTIMORE FIRE.*

By John Stephen Sewell.†

I have the honor to submit the following report of observations made by me in Baltimore, Md., on the so-called fireproof buildings which were within the burned area during the recent conflagration. My observations were made with the special view of arriving at some measure of the efficiency of current methods of fireproofing, when subjected to a severe test. I visited Baltimore three times, once on Feb. 14, a few days after the fire, while the ruins were still hot and smoldering; once on Feb. 27, after some progress had been made in clearing away the debris; and again on March 10, 1904, to witness a test on one of the systems of floor construction that had come through the fire.

On the occasion of my first visit, I was unable to get into the buildings, and had to be content with as thorough a survey as possible from the outside, with the aid of a good field glass. On my second and third visits, through the courtesy of the Building Inspector of Baltimore, I secured access to a number of the damaged steel frame buildings, and had good opportunities for close and accurate observation. Through the courtesy of the Baltimore Ferro-Concrete Co. I secured access, on my third visit, to a number of interesting points.

THE TEMPERATURE OF THE FIRE.

In my judgment, the temperature of the fire did not at any time or place exceed 2,000° F., and in general, it was much less than this. In the ruins of one non-fireproof building I saw a broken cast-iron column in which the broken edges had become slightly smooth and rounded;

*Report made to General A. Mackenzie, Chief of Engineers, U. S. Army.

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the metal was apparently on the point of melting. In the steel frame, fireproofed buildings I saw here and there a door lock with the bronze or brass parts partly melted. I saw a good deal of melted glass, but it did not present the appearance of having flowed freely, in any place. Some silverware is reported to have melted in several places. I saw some iron shutters which, from the street, looked as though small parts had melted away, but was not able to determine this with certainty. All the visible facts indicate a temperature of from 1,200° to 1,800° F. It was long continued, and in many cases did more damage than a higher temperature of shorter duration would have done. It may be noted that Prof. Ira A. Woolson, in the Engineering News of March 3, 1904, expresses views similar to the above, as to the temperatures prevailing during the fire.

NATURE OF THE LESSONS TAUGHT BY THE FIRE.

With one or two exceptions to be noted hereafter, nothing happened which could not have been absolutely predicted from a study of the records of fires and fire tests already available. The conditions which made this great conflagration possible are duplicated to a greater or less extent, in every large city in this country. If this fire shall awake owners and municipalities to an appreciation of the truths plainly evident in existing records, it will prove a blessing in disguise.

DESCRIPTION OF DETAILS.

I went into the following buildings: The Continental Trust, The Maryland Trust, The Calvert, the New Custom House, and a small reinforced concrete building at No. 111 German St. I examined, from the street, and from good points of view in other buildings, the Union Trust, the Equitable, the Chesapeake & Potomac Telephone Buildings, the B. & O. Central, and many others, the names of which will be noted later.

SOURCE OF IGNITION.—In all of the fireproof buildings the fire was introduced from without. This was the primary cause of the combustion of all their contents; but the exterior fire spent its force mainly on the steel and masonry of outer walls, and the test of the interior fireproofing was due almost entirely to the burning of the contents of the buildings.

In the case of the Continental Trust Building, the draft may have carried the flames from the surrounding fire through some of the corridors and rooms; but, in general, what damage was done to interiors, was due to fires in the buildings themselves; what happened in this fire on a large scale, due to the simultaneous ignition of all the contents, would happen, and has happened, locally, in the event of the burning of the contents of one room or one floor; the damage in this case would be almost as severe, though less extensive than that which actually occurred in Baltimore.

EXTERIOR WALL DAMAGES.—In the matter of exterior walls, both stone and terra-cotta suffered severely; the former was to be expected; the latter is something of a surprise, although there are records enough of hollow terra cotta failing under expansion strains when heated. Still, it was thought that architectural terra cotta was reasonably fireproof when used in external walls. Its behavior in Baltimore is a distinct disappointment, for it can no longer be classed as a fireproof material.

Practically all the building stones exposed to the fire, spalled and chipped, ruining many of the individual pieces. The terra cotta cracked and fell to pieces, and in some cases its color was changed and the heat seemed to have destroyed its texture so as to render the material itself soft and friable. Stone with projecting parts of any kind suffered more than similar stones entirely flush with the wall; highly ornamental terra cotta suffered notably worse than that which was relatively plain. Some varieties of stone suffered less than others, but in the absence of exact knowledge as to the distribution of heat, it is unsafe to draw conclusions as to the relative value of the different stones for resisting fire. No stone commonly used for architectural effect is fireproof. Probably granite spalls as badly as any, if not worse. Certainly that used in the new Custom House spalled freely under moderate heat. I think the effect here was aggravated by the fact that most of the ashlar was cut with raised panels in the center; this exposed a relatively small mass of each stone to sudden changes in temperature, while the body of the same stone remained relatively cool. Marble spalls, not so badly as granite, but still very badly; of course, long-continued heat calcines it, and ruins it, whether it is spalled or not.

In the case of the ornamental terra cotta, it is possible that filling all the cavities with concrete might improve its fire-resisting qualities by preventing the exposed parts from getting so hot as they do when backed by a dead air space, yet I saw some pieces in the Maryland Trust Building which had been filled with mortar, but which failed, nevertheless.

Of materials used in exterior walls, properly bonded brickwork was the only thing that was really successful. Even here, bricks that were very dense, or burned very hard, spalled more or less, but not enough, in most cases, to require renewal. Face bricks laid up without other bond than metal ties were stripped bodily from the wall, in large areas, as in the case of the side and rear walls of the Continental Trust Building. This is a new and strong argument against a very prevalent, pernicious practice, and it is to be hoped that it will be the beginning of the end. Common brickwork stood the best of all. It is a noticeable fact that, even in the non-fireproof buildings, where a stack of brick vaults existed, running through the different stories, these were intact, standing up conspicuously among the ruins. On the occasion of my second visit, the former tenants of the burned buildings were removing their books and valuable papers from these vaults, in good condition, thanks to well-bonded common bricks.

The walls of the Continental Trust Building are in very bad shape, especially the south, east and court walls. Here was where the face brick stripped off; here the beams carrying the walls are nearly all warped and twisted, and the walls are so bulged and cracked that they ought to be taken down entirely. There is serious damage to the north and west walls, also, but probably it can be repaired without tearing them down. The spandrel, or wall-carrying beams in this building were built up tees, placed at the level of the window heads in each story, so as to act as lintels; their only protection was the ornamental terra cotta trim, which failed utterly during the fire. Had these beams been adequately protected, probably the damage to the walls of the east and south sides, and the court would not have been more than half as great as it was. A careful study of existing records would, I think, have raised grave doubts as to the adequacy of the fire-protection on these particular beams, even without the light shed on the question by the Baltimore fire. The south, east and court walls were much more severely tested than the north and west walls; once the spandrel beams begun to bend and twist, the ruin of the walls was inevitable. The design of these badly damaged walls was very light, and the workmanship inferior. Had they been more substantial in design and better built, the damage would have been much less.

The exterior walls of many of the other so-called fireproof buildings ought to be taken down; all of them are more seriously damaged than appears, except upon close inspection. This applies to all the walls of the Union Trust Building, of the Calvert Building, to the rear and court walls of the Equitable Building, and to parts of the walls of the B. & O. Central Office Building. No doubt the same is true of still others.

I believe that better results would be obtained by building the exterior walls continuously from the foundation up, anchoring them carefully to the steel frame to prevent buckling. The beams carrying the walls are often so near the surface, especially where they act as lintels, that in a long-continued fire they get hot enough to expand and bend; this will wreck the wall, if nothing else does. If the weight of brickwork is assumed at 125 lbs. per cu. ft. and its safe-working load at 20 tons per sq. ft., a wall of uniform thickness and 320 ft. high will be safe under its own weight, so far as crushing is concerned. With a very moderate increase in thickness near the bottom, and thorough anchorage to the steel frame at all points, a self-supporting brick wall is entirely practicable for any steel-frame building. Its only drawback is the time required to build it, for it could not be started on a number of levels at the same time. This, however, would probably result in better work. The modern building erected in record-breaking time, is never a model of workmanship, and often it contains defects, that reduce the factor of safety almost to unity. The standard of work that prevails in these hastily erected structures would not be tolerated for a moment in general engineering works.

Outside curtain walls in fireproof buildings should be continuous from the foundation up, with a minimum thickness of at least 8 ins. or two bricks (except in small areas such as window recesses) and thoroughly bonded with real headers throughout.

PROTECTION OF WINDOW OPENINGS.—But the weakest point of all exterior walls is the windows, from the point of view of fire prevention, at any rate. I believe that such curtain walls as are described above, would have stood practically uninjured in the Baltimore fire; but they would not have saved the contents of the buildings, with the windows as they were. On most of the fireproof buildings there were no fire shutters at all; where there were shutters, they appeared on only one or two faces and were of no use, because the fire would have gotten through unprotected windows on the other fronts, anyway.

I think outside metal shutters, hung in the ordinary way, would fail to keep out such a fire as that in Baltimore, in any event, because they soon warp and twist and then do not fit closely enough; moreover, if the windows had wooden sash and frames, these would probably be ignited by their proximity to the hot shutters, if in no other way; and thus the fire would spread to the interior. Wooden shutters covered with sheet metal would probably do no better, because the wood would char by destructive distillation, and destroy the hold of the screws or other means used for fastening on the hardware.

In the first place, window openings should be as small as is consistent with proper light. Up to a certain point, it costs more to build a window into a wall than it does to build the wall solid. There is a limit, however, beyond which windows are cheaper than solid walls. The window area in the Continental Trust Building was far beyond this limit. It may have been made so in response to unreasoning demands for light; and it may have been done with a view to a low first cost. In any event, it was too great. The same was true of many other buildings.

If wooden frames and sash are to be used, the fire shutters should be on the inside. They should be hung from the top, so as to suffer none but tensile stresses when hot; this naturally suggests a rolling shutter of sheet metal. The axle and journals should be covered in with brickwork at the top, so as to be protected from excessive temperatures, as far as possible. In a window protected in this way, and exposed to a fire such as that at Baltimore, the window frame and sash, and the shutter itself, would be a total loss; but the fire would probably not enter the building.

If metal frames and sash, or frames and sash of any other incombustible materials, and wired glass are used then the shutter would better be on the outside; if walls are made of proper thickness, they could be so placed without marring the appearance of the front. In this case, the metal shutter only would be a loss in the event of fire.

Rolling shutters should not be made of very light metal. I saw a number that had been installed on the outside of buildings in Baltimore, in which the shutter was made up of several sheets of light corrugated iron riveted together along horizontal lines. When these were heated, the sheets pulled apart along the highest line of rivets, thus exposing most of the window opening to the flames. Probably a rolling shutter made of heavy interlocking slats, or slats fastened together with heavy links, would be better. Still better would be one or two sheets of metal, stiffened around the edges properly hung, and sliding in the window frame just like the sash; this would necessitate a specially designed frame with a high boxed head, to permit of sliding the shutters up so as to clear the opening; but with walls of proper thickness, it could readily be provided. That part of the frame carrying the shutters should be of metal, and pocketed into the brickwork, with a little room for expansion.

Slender mullions, whether of metal, terra cotta, or bricks suffered severely in the Baltimore fire; they are a positive disadvantage in any window opening, and dangerous if they carry weights. It is much better to have all window openings single, and no light piers of any sort in the outer walls, whether they are classed as mullions or not.

The cast-iron window frames in the B. & O. Central Building stood well, although the parting beads and staff beads buckled so they will have to be renewed.

Metal sash and frames, with iron shutters inside, kept the fire out of the Appraiser's Warehouse; even the glass was not broken. The fire gained access, however, through a ventilating skylight in the roof and destroyed part of the contents. The behavior of the floor construction in this building was interesting and will be referred to later.

So far as I was able to determine, both slate and tile roofs kept out the fire, with some damage to themselves.

I saw no wired glass that had been subjected to the fire, but I understand there was some, which stood very well.

So far as the main framework of all the fireproof buildings is concerned, the outer walls seem to have protected it very well. Only the spandrel beams, carrying the walls, seem to have suffered from the external fire, and these are a very small part of the steel frame.

DAMAGE TO INTERIOR FIREPROOFING.—Coming now to the interior fireproofing, this consisted almost entirely of hollow tiles, mostly of clay, but some of a composition known as lime-tell in the Baltimore market. There was a small amount of cinder concrete floor construction on steel beams, and a small amount of reinforced concrete construction, including reinforced concrete columns and beams, within the burned area. Partitions were mostly of hollow tiles, cinder concrete, plaster of Paris compositions, and brick.

Column coverings were practically all of hollow tiles; some partition work and girder covering were executed in metal, lath and plaster. I understand that some lime-tell partitions were used in the Equitable Building, but did not verify it. I saw the ruins of some cinder concrete partitions in the Calvert Building.

The only successful partitions were brick walls. These lost their plaster, but were otherwise undamaged. The hollow terra cotta partitions suffered, in the general average, at least 85% damage, if not more. Many vaults in the Continental Trust Building, walled in with hollow terra cotta, failed and their contents were burned. All other partitions of all sorts were a total failure. Metal lath and plaster failed everywhere.

The only column coverings I noted were of hollow terra cotta; while, in nearly every case, they had saved the column from damage, they were a total loss themselves; I examined the column coverings in many cases; all were so badly damaged that they ought to be entirely removed.

Of the various types of floor construction, lime-tell hollow blocks apparently stood the best. But it is to be feared that this success is more apparent than real, because of the liability of this material to be seriously damaged by calcining. Hollow tiles offered both the best

and the worst examples of floor construction. They were more extensively used than anything else; this explains the variation in results, and also the high average percentage of damage they suffered. Concrete stood very well, but had not been very extensively used; what examples there were had been very well executed. This was not true in all cases of the hollow tile work. The general average of loss in hollow terra cotta floors was not less than 50%, if all damaged tiles are renewed, as they ought to be. In the Calvert Building, flat hollow terra cotta end construction arches are practically a total loss. In the Equitable Building, end construction segmental arches of hollow terra cotta, are a total loss, in fact, more than a total loss, for the wrecked arches must be cleared away before repairs can begin. The best and only good bit of floor work in this building that can be discovered from the street, is a small mezzanine floor of cinder concrete in the rear of what was apparently the main office room on the first floor. This stands, practically uninjured, covered with the debris of the wrecked hollow tile floors. In the Continental Trust Building, side construction arches of hollow terra cotta came through with not more than 25% damage. In the telephone building, the same holds true. A small floor of this sort in the Bank of Baltimore building, has the tiles intact, but the steel beams in one-half of the area are so badly deflected that the whole will have to come out. In the Maryland Trust and the Union Trust buildings, hollow terra cotta floors stood about as in the Continental Trust Building, perhaps not quite so well. Had these floors been heavily loaded, it is probable that many beams which are not damaged, would have suffered permanent and serious deflection; this would have involved total loss of the flat arches.

In the building of the Merchants' & Miners' Transportation Co. were a number of segmental brick arches on I-beams, without fire protection for the lower flanges of the beams. Some of these had collapsed, either from the softening and bending of the beams, or from debris precipitated on them from above; some, however, were still in place and uninjured, but the beams were deflected so that they ought to be taken out. In the Appraiser's Warehouse, some groined arches, built of bricks, and supported by granite piers, were absolutely uninjured, though the granite piers were almost destroyed.

In the Equitable Building, the segmental arches did not have the haunches leveled up with concrete, as they should have been; the floors were laid on light sleepers spanning the inequalities due to the curve of the arches; a number of heavy safes were on these floors, and as the timber was weakened, the safes fell through, wrecking both arches and beams. But apart from this, the tiles lost their lower webs everywhere, and the beams deflected very seriously, so that in my judgment, the tile floors in this building would have been a total loss in any case; the floor beams and girders are damaged at least 30%; probably by the time they are repaired, the loss will prove still greater.

In the Calvert Building, the damage to the hollow terra cotta floor arches was the loss of the lower webs, which was general throughout the building; in this building, hower, the floor beams and girders remained straight and true. One column was badly buckled, and will have to come out. All the column coverings will have to be removed. It has been stated that much of the damage to the column coverings here and elsewhere was due to the heating and buckling of iron pipes carried up in the space between the columns and their coverings; with this I can not agree, for the pipes in many cases, had their coating of paint perfectly fresh and undamaged, and they themselves were straight and true; yet the column covering was so badly damaged as to be beyond repair. I think that in all cases the column covering failed first. Where this occurred early enough in the fire, the pipes inside were heated and buckled, probably aggravating the failure of the covering; but, had the covering remained intact, the pipes would not have become hot enough to do any damage.

In the Continental Trust Building, the Maryland Trust, and the Union Trust, the damage to hollow terra cotta floors was the loss of lower webs, as in all other cases. In the Continental Trust, column coverings of hollow terra cotta are a loss throughout.

Hollow tile floors of lime-teil in the B. & O. Central Office building, the Firemen's Insurance Building, the Chamber of Commerce, and one or two other smaller buildings, stood well. I saw no evidence of damage except in one case where a pile of debris had fallen on one of these floors. Possibly the heat recalcined the material to some extent, as it seems to be made of lime, plaster of Paris, and cinders or slag; I was not able to determine this. What effect water would have on this composition in its heated state was not determined. In the Chamber of Commerce building, some one had cut through the lower webs of the lime-teil blocks, and the minimum thickness of the material was about 1½ ins. At the junction of webs it was much thicker, as the hollow spaces inside had a nearly circular or elliptical cross section. I think the thickness of the material was the vital cause of its apparent success. Where lime-teil was used for partitions, it failed just as other materials did.

In the Bank of Commerce Building, there were some cinder concrete floors, which stood very well, notwithstanding the fact that some bits of partly burned coal, on the exposed faces of the floor slab actually caught fire and burned out. The same was true of the small mezzanine floor already referred to, in the Equitable Building.

REINFORCED CONCRETE CONSTRUCTION.—A small building at No. 111 E. German St., was built with reinforced concrete columns, beams, and floor arches, on the Hennebique system; it belonged to the United States Fidelity & Guaranty Co. It was surrounded by non-fireproof buildings, and was subjected to an extremely severe test, probably involving as high temperature as any that existed anywhere. The concrete was made with broken granite as an aggregate. The arches of the roof, and the ceiling of the upper story were cracked along the crown, but in my judgment very slight repairs would have restored any strength lost here. Cutting out a small section—say an inch wide—and caulking it full of good strong cement mortar would have sufficed. The exposed corners of columns and girders were cracked and spalled, showing a tendency to round off to a curve of about 3 ins. radius. In the upper stories, where the heat was intense, the concrete was calcined to a depth of from ¼ to ¾-in., but it showed no tendency to spall, except at exposed corners. On wide flat surfaces, the calcined material was not more than ¼-in. thick, and showed no disposition to come off. In the lower stories, the concrete was absolutely unimpaired, though the contents of the building were all burned out. In my judgment, the entire concrete structure could have been repaired for not over 20% to 25% of its original cost. On March 10, I witnessed a loading test of this structure. One bay of the second floor, with a beam in the center, was loaded with nearly 300 lbs. per sq. ft. superimposed, without a sign of distress, and with a deflection not exceeding ⅛-in. The floor was designed for a total working load of 150 lbs. per sq. ft. The sections next to the front and rear walls were cantilevers, and one of these was loaded with 150 lbs. per sq. ft. superimposed, without any sign of distress, or undue deflection.

The floor construction of the International Trust Building was also of reinforced concrete. It came through undamaged, but did not get as much heat directly applied, as did the building at 111 E. German St. However, the heat was at least as intense as in the case of many other fireproof structures which did not fare so well. A lot of silverware stored on the floor of the banking room was entirely melted; the contents of the building above the basement were completely burned. Many experiments and tests from the days of Thaddeus Hyatt and his private experiments in England, nearly thirty years ago, to the present time, have shown that concrete is entirely suitable for fireproof floor construction, when properly combined with steel. The results at Baltimore corroborate existing evidence on this point. But one fact indicated in all these tests and fires is this: As the material is calcined and damaged to some extent by heat, enough surplus material should be provided to permit of a loss of say ¾-in. all over exposed surfaces, if the structure is to be exposed to fire; moreover, all exposed corners should be rounded to a radius of about 3 ins. This latter precaution would add much to the resistance of all materials used in masonry whether bricks, stone, concrete or terra cotta—if they are to be exposed to fire.

It seems a little strange that the tiles in the floors suffered less than those in the partitions; but in the case of the Continental Trust, there were probably powerful horizontal drafts through the building, and these may have caused the flames to be more directly applied to partitions than to ceilings. In all of the other fireproof buildings, the floor tiles suffered about as much as the partition tiles. The trouble with the hollow terra cotta tiles, as commercially applied, is that they have been skinned down to a minimum thickness; the webs are rarely more than ⅝-in. thick. When exposed to the fire, they soon get red hot; the rest of the tile, being surrounded by dead air spaces, remains cool; the change in temperature near the junction of exposed and non-exposed webs is so rapid, that stresses are set up exceeding the strength of the material, and the exposed web drops off. If it does not do this under the heat alone, a stream of water from the nozzle of a fire hose quickly brings about the same result. If the material in the hollow tiles were made thicker, so that the entire variation in temperature would occur within the thickness of the exposed web, these stresses, tending to detach the web, would not exist; and a steel frame, covered with such tiles, would form a structure able to resist many fires, with no loss to itself worthy of note. From such data as I have been able to gather, I should say that if all hollow tiles were made of porous terra cotta, with webs not less than 1½ ins. thick, they would come through a fire not only protecting the steel work, but suffering practically no damage themselves; provided always that they are made of a well selected tough and refractory clay.

As commercially applied, hollow terra cotta column coverings are very flimsy; girder coverings are a little better, and the flat floor arches are the best of all, but these are none too good. The order of merit ought to be reversed, the column coverings ought to be the strongest feature, the girder covering next, while the floor arches might be the weakest, but all ought to be stronger than they are now.

It is worthy of note that wherever the plaster was strong enough to adhere throughout the fire, the fireproofing was much less damaged than where the plaster fell off. Flat arches stood better than segmental arches of the same materials. Side construction stood better than end construction, but the material in this case was almost invariably thicker than in the end construction arches.

COST OF COMPLETE REPAIRS.—Considering the site of the fireproof buildings as a whole, as exemplified by the Continental Trust, the Calvert, the Union Trust and the Equitable buildings, the cost of fully restoring them will be not less than 60% of their original value. It may be possible to render them habitable for less, but they will not be as presentable nor as secure against fire as they were in the beginning. When the cost of removing debris is considered along with the cost of the new work required, the loss on various items of these buildings I think, will average about as follows; the estimate is based on a necessarily hasty examination, and the hypothesis of complete repairs:

	Per cent.
Steel frame	10
Outer walls	50
Floor systems	50
Partitions	80
Column coverings	100
Mechanical equipment	100
Trim and finish	100
Office furniture	100
Contents of vaults	25

LESSONS FOR FUTURE CONSTRUCTION.—From the point of view of the tenant whose vault failed, the fireproof buildings are a delusion; the tenant in the non-fireproof building, who had a brick vault, was better off, for he lost only his office furniture. From the point of view of the owner, the fireproof building justified itself; in the first place, he could not have had so high a building, with so much rentable space, without the use of steel; if this steel had not been fireproofed, he would now have a foundation, covered with tons of twisted steel and a pile of bricks; as it is, he has a foundation, a steel frame practically intact, and a greater or less percentage of his walls and fireproof coverings still in place and serviceable. In a very short time, comparatively speaking, his building can be again ready for tenants. Even if he could have used wooden beams and columns, he would have had only a pile of bricks and a mass of twisted pipes, besides the foundation. In any case, his fireproofing was well worth what it cost.

Looking at the matter from the point of view of the tenant, however, a number of improvements ought to be made. The most crying need of all is protection against outside fires; this means windows of minimum area, efficient fire shutters, incombustible frames and sash, if possible, and means for surrounding the entire building with a curtain of falling water, delivered from the cornice. The latter is practicable, and there is little doubt that, if made reasonably heavy, it would save a building otherwise certain of serious damage. Skylights and other openings in roofs should be reduced to a minimum and carefully guarded. Nothing combustible should be used in the roof finish.

After adequate protection from outside fires, the point of first importance is prevention of fires on the inside. Sprinkler systems should not be neglected, even in fireproof buildings; trim should be incombustible as far as possible, and everyone should be encouraged to use incombustible office furniture. After these matters are attended to, improvements could well be made in the structure itself, and the prevailing types of fireproof covering. As no building can be really fireproof, it may be well to suggest a definition for this term. It is suggested that, to deserve this name, a building should be able to come through not only one, but a number of fires, with no damage except the loss of combustible contents, cracked glass, loss of paint and plaster, damage to marble finish, and possible warping of exposed metal work such as lighting fixtures, elevator enclosures, balustrades, etc. This involves the use of a minimum of stone and ornamental terra cotta in the outer walls. If the terra cotta is made very heavy, however, it is probable that it would resist the fire sufficiently well. It involves the use of bricks of reasonably refractory clay, burned to the point of maximum toughness, but not to vitrification; the use of incombustible trim; of column coverings, at least equal in efficiency to 4 ins. of brickwork, with all the interior space filled with Portland cement concrete; of girder coverings, beam protection, and floor systems much heavier than the prevailing forms of hollow terra cotta; of hard wall and ceiling plasters—the best of which is made by incorporating a fair proportion of Portland cement with ordinary lime mortar plaster, and, finally, a more rigid supervision and a better standard of workmanship than are now prevalent. Rounded corners in brickwork, plastering, fireproofing, etc., should be used for all salient angles; if left square, they all tend to spall under the fire.

Considering the various materials used for fireproof coverings, the following is a statement of facts well established by the existing record of fires and fire tests:

BRICKWORK.—Most efficient of all. Undergoes no molecular change in the fire; if of hard, tough refractory

bricks, not vitrified, and well bonded, will stand the application of both fire and water many times without damage to itself.

HOLLOW TERRA COTTA.—Undergoes no molecular change, if of tough and refractory clay; suffers large percentage of loss in its commercial forms owing to mechanical failure under stresses due to expansion and contraction. If made porous, of good clay, with minimum thickness of material not less than 1½ ins., would probably be about equal to brickwork.

BEST FORM OF FLOOR ARCH.—Either segmental arch of bricks or concrete, with heavy protecting skewbacks for floor beams, or flat arch of hollow terra cotta, made of porous material not less than 1½ ins. thick, or flat slab of gravel, brick, or slag concrete.

CONCRETE.—Undergoes more or less molecular change in fire; subject to some spalling. Molecular change very slow. Calcined material does not spall off badly except at exposed square corners. Efficiency on the whole, is high. Preferable to commercial hollow tiles for both floor arches or slabs, and column and girder coverings. In form of reinforced concrete columns, beams, girders, and floor slabs, at least as desirable as steelwork protected with the best commercial hollow tiles. Stone concrete spalls worse than any other kind, because the pieces of stone contain air and moisture cavities, and the contents of these rupture the stone, when hot. Gravel is stone that has had most of these cavities eliminated by splitting through them, during long ages of exposure to the weather. It is therefore better for fire-resisting concrete than stone. Broken bricks, broken slag, ashes and clinker all make good fire-resisting concrete. Cinders, containing much partly burned coal are unsafe, because these particles actually burn out and weaken the concrete. Locomotive cinders kill the cement, besides being combustible. On the whole, cinder concrete is safe only when subjected to the most rigid and intelligent supervision; when made properly, of proper materials, however, it is doubtful whether even brickwork is much superior to it in fire-resisting qualites, and nothing is superior to it in lightness, other things being equal.

PLASTER OF PARIS COMPOSITIONS.—These all calcine easily at moderate temperatures. They are not suitable for use except under special conditions, which do not often arise.

PLASTER.—On metal laths, when at its best, this material is like the average run of hollow terra cotta, though not quite so good; it protects the steel, but is a total loss itself. Applied to other fireproof coverings, it will in itself resist fire a long time, and thus lessen the severity of the test for the material behind it.

PARTITIONS.—None of the light partitions in common use is a success. Heavy hollow terra cotta, or walls of brick or concrete from 4 to 9 ins. thick would be much better. Fireproof vaults with walls of commercial hollow tiles are a failure. The walls should be of bricks, and the floors and ceilings extra heavy, even if more steel has to be introduced to carry them.

If all the improvements above suggested were introduced at once, they would increase the cost of fireproof buildings probably about 15%. Whether this is worth while, or whether any part of it is worth while, is for those whose interests are at stake to determine. There is no question that it is worth while in government buildings, and it is probable that consideration from a comprehensive point of view would show that it is true economy, even in private work. One thing is certain; the execrable workmanship that prevails in current commercial buildings renders drastic building laws necessary, in the matter of allowable strains and stresses. If owners would always pay for intelligent and thorough supervision, these laws might be much relaxed, and buildings would be both cheaper and better. A little good workmanship would have saved much of the damage in Baltimore, even without any improvement in type or design.

PRESIDENT ROOSEVELT'S INSTRUCTIONS TO THE ISTHMIAN CANAL COMMISSION.

The President, under date of March 8, has issued the following letter of instruction to the Isthmian Canal Commission:

I have appointed you as the commission which is to undertake the most important and also the most formidable engineering feat that has hitherto been attempted. You are to do a work the doing of which, if well done, will reflect high honor upon this nation, and when done will be of incalculable benefit, not only to this nation, but to civilized mankind.

As you yourselves must individually know, I have chosen you with reference to nothing save my belief, after full and patient inquiry, that you are among all the available men of whom I have knowledge those best fitted to bring this great task to a successful conclusion. You have been chosen purely because of your personal and professional reputations for integrity and ability. You represent the whole country. You represent neither section nor party. I have not sought to find out the politics of a single one of you, and indeed as to the majority of you I have not the slightest idea what your political affiliations are. I believe that each one of you will serve not merely with entire fidelity, but with the most efficiency.

If at any time I feel that any one of you is not rendering the best service which it is possible to procure, I shall feel called upon to disregard alike my feelings for the man and the man's own feelings and forthwith to substitute for him on the commission some other man whom I deem capable of rendering better service.

Moreover, I shall expect, if at any time any one of you feels that the work is too exhausting for him to do in the best possible manner, that he will of his own accord so inform me in order that I may replace him by some man who to the requisite ability joins the will and the strength to give all the effort needed. But so long as you render efficient service of the highest type in the work you are appointed to perform, you may rest assured of my hearty support and backing in every way.

These are the conditions under which you have been appointed, and under which I shall expect you to proceed. I shall furthermore expect you to apply precisely the same principles in the choice and retention of the subordinates who do the work under you as I have applied in your choice, and shall apply in your retention. I shall expect you to appoint no man for reasons other than your belief in the aid he can render you in digging the canal.

If, having appointed any man, you find that your expectations about him are not fulfilled, or that from any reason he falls short of his duty, I shall expect you to dismiss him out of hand; I shall expect that under the circumstances you will pay not the slightest heed to any backing or influence the man may have.

I assume as a matter of course that in dealing with contractors you will act on precisely the principles which would apply in any great private business undertaking. There is no man among you to whom I think it is necessary to say a word as to the standard of honesty to be exacted from every employee or contractor; for if I had had the slightest ground for suspicion that there was need to such say a word to any one of you, I should not have appointed him. But I do wish to emphasize the need of unceasing vigilance in the performance of this great work.

As to the details of the work itself, I have but little to say. It is to be done as expeditiously as possible and as economically as is consistent with thoroughness. There is one matter to which I wish to ask your special attention—the question of sanitation and hygiene. You will take measures to secure the best medical experts for this purpose whom you can obtain, and you will, of course, make the contractors submit as implicitly as your own employees to all the rules and regulations of the medical department under you. I presume you will find it best to have one head for this medical department, but that I shall leave to your own judgment.

The plans are to be carefully made, with a view to the needs not only of the moment, but of the future. The expenditures are to be supervised as rigorously as if they were being made for a private corporation dependent for its profits upon the returns. You are to secure the best talent this country can afford to meet the conditions created by every need which may arise. The methods for achieving the results must be yours. What this nation will insist upon is that the results be achieved.

A STREET RAILWAY SUBWAY system for Chicago is again being talked of, and is now suggested in connection with the necessity of lowering the three river tunnels of the cable lines to permit the navigation of the river by large lake steamers. The tunnels must be lowered 17 ft., which would involve long and steep approaches, which would be avoided by the subway connections. The city proposes to build the subways and charge a rental for their use which would more than pay the interest on the cost of the bonds issued for carrying out the project. The present plan is to build two single track loops, one for each of the tunnels leaving the third tunnel to be dealt with later. The Washington St. portion would be double track as it is included in both loops. The routes proposed are as follows: La Salle St. tunnel; La Salle, Washington, State, Randolph and La Salle Sts. Washington St. tunnel; Washington, State, Madison, La Salle and Washington Sts. The cost is estimated at $3,500,000 for lowering the two tunnels and $1,000,000 for the subway loops. The council committee has directed Mr. Spengler, Assistant City Engineer, to prepare the necessary plans, which will probably be ready by June.

THE OLD MORRIS CANAL in New Jersey has been practically disused for traffic for several years. It is leased by the Lehigh Valley R. R. Co. and would have been abandoned long ago except for the fact that it carries valuable water rights which would revert to the state if the use of the water for canal purposes were to cease and the canal were abandoned. Legislation has been sought by the canal interests permitting the sale of these water rights; but has been refused and a year ago a commission made up of ex-Governors Werts, Griggs and Voorhees was appointed to report on the matter.

This report has just been made and favors the abandonment of the canal, provided the Lehigh Valley R. R. Co. consents to surrender its lease. With this done the canal and its water rights would be sold and the proceeds used to pay the outstanding bonds of the canal company, amounting to $565,000 and to cancel the $2,200,000 stock of the company at an appraised valuation. The balance if any would revert to the state.

THE VALIDITY OF SEPTIC TANK PATENTS before the courts in litigation in which the City of Plainfield, N. J., is the defendant and the Cameron Septic Tank Co., of Chicago, is the plaintiff. The bill charges infringement of patent No. 634,423 granted to Cameron, Commin and Martin in October, 1899. The City of Plainfield is also defending a suit by the American Sewage Disposal Co., of Boston, John N. McClintock, President, for the infringement of patent No. 559,522.

A MUNICIPAL GARBAGE CREMATORY is likely to be established at Plainfield, N. J., as a result of the investigations of a joint committee of the Common Council and the Board of Health. It is proposed to purchase and put in working order the Vivarttas Crematory in Plainfield, built by the Plainfield Sanitary Co. in 1897, but abandoned after a few months' use owing to financial difficulties.

THE CORONER'S FINDING ON THE DARLINGTON collapse of March 2 was announced on March 23. The inquest lasted nearly two weeks, and the jury was composed wholly of men experienced in building and iron work. The finding holds the iron contractors (the firm of Pole & Schwandtner) and the head of the owning company (Eugene F. Allison) responsible for the collapse:

We find that the collapse was due to defective designing, a total absence of competent supervision, and the employment of inexperienced contractors. We further find that Eugene F. Allison and the firm of Pole & Schwandtner were grossly criminally negligent in the methods adopted and followed by them in the erection of said building.

We recommend that the practice of the erection of buildings without the superintendence of the original architect or a competent builder of at least five years' experience, be prohibited by law.

We further recommend that the Building Department of the City of New York have a corps of competent engineers to inspect the erection of all buildings requiring engineering skill, and that a copy of the approved plans of each building be kept on the premises during construction.

It will be seen that the direct cause of the collapse is not given. Mr. H. De B. Parsons, who had been retained as expert by the District Attorney of New York County, charged the failure to loose connections, weak construction, and the absence of bracing, so that the columns acted as long columns. He holds that the initial break occurred at about the third or fourth floor, and was a column failure rather than a floor failure. He deduces the location of the initial break from the fact that the walls and wall columns remained standing up to about the level mentioned.

THE EXAMINATION AND LICENSE OF ARCHITECTS is provided for in a bill introduced in the New York legislature. Recent revelations in New York city would suggest the wisdom of a supplementary enactment compelling owners of real estate to employ such licensed architects to plan and supervise building of such size as to affect public safety.

THE CONSTRUCTION OF THE BOHIO DAM, says Admiral Walker, in answer to questions from the Congressional opponents of the Panama Canal, constitutes the great engineering feat of the whole enterprise. He says it will be necessary to go 120 ft. deet for safe foundations; but he also believes that it is feasible to build the dam. The material to be penetrated is very ununiform in disposition, and permeable strata show themselves in every boring out of 86.

COAL PIERS WITH ELEVATORS instead of inclines to serve the upper deck where cars are unloaded into the pockets, have been suggested by Mr. H. R. Talcott, Assistant Engineer of the Baltimore & Ohio Ry., in a discussion on the report of the Committee on Yards and Terminals, of the American Railway Engineering and Maintenance-of-Way Association. Mr. Talcott outlines his plan as follows:

For some years the Seattle Coal & Iron Co. operated an hydraulic hoist, which, with a 30-in. piston, using water from the city mains, raised cars loaded with coal to the top of the retail bunkers. In discussing the plans for a coal and ore pier designed to have pockets for both discharging into steamers at the sides and into cars under the center of the pier, it occurred to me that an hydraulic hoist could be used to lower the empty cars, vertically, to below the pockets and save the space that would be cut out by a return incline from the end of the pier.

The hoist would be regulated by a gate valve, set below the water surface, through which the water would be drawn into the piston casing as the piston and empty cradle were drawn up by counterweights, and by which the descent with the empty cars would be regulated. By using a rigid frame on the head block of the piston and a pivoted cradle for the cars on that, the weight of the car could be made to release the pressure from the chocks, to allow them to be withdrawn easily for lowering, and a suitable block at the bottom would tilt the cradle and discharge the empty car.

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We said last week in this place that the responsibility for safe building construction in a city rests and ought to rest on the owner and those whom he employs, and not on the Building Law or the Building Department. In the Darlington inquest in New York City during the past week, however, abundant evidence has appeared that owners and contractors alike are working on the basis that any plans which will pass the Building Department are good enough so far as safety is concerned.

The original plans for the Darlington were prepared by a firm of architects, but when these plans were offered to builders by the realty company owning the property, they were overwhelmed with offers to lower the price for the work by cutting down the amount of ironwork. A contract was finally made for the erection of a building on the original architects' plans, but Mr. Allison, the Secretary of the real estate company for whom the building was intended, testified on the witness stand as follows:

I wish to tell the truth. Mr. Schwandtner wanted to reduce the quantity of iron, and our people told him that if the Building Department would pass Mr. Waite's plan (one prepared by a competitor on the claim that it would reduce the cost of the ironwork) we could have no objection to his following it.

The man who gave this testimony was a lawyer, and supposedly a competent business man, but he had evidently no idea that he was trifling with most serious danger in permitting such irresponsible and incompetent work in connection with the frame of his building.

Later, he found, when work on the building had commenced and two stories of the framework were up, that the iron contractors were working on plans of their own, but he took no action except to say to the contractors that "they had frightful nerve to draw extra plans without our consent or that of the Building Department."

When the ironwork was erected for nine stories it was found to be 18 ins. out of plumb, and was pulled back to position with tackle. This came to the knowledge of the owner; but all he did was to call up the Building Department on the telephone and drop the matter when he found the Inspector in whose district the building was located was not in the office. Later he "consulted" an engineer as to whether the swaying of the building out of plumb involved any danger, and was reassured by an opinion that if any trouble was to come it would have manifested itself when the building was first hauled back to place. Apparently this "consultation" was nothing more than a casual conversation, which did not cost the owner anything. To part with good money for such a thing as expert advice was evidently contrary to all his ideas of sound business.

Later on he testified

that he had voluntarily added $200 to the $1,000 which the company agreed to pay Neville & Bagge for the plans; that no saving in steel which Pole & Schwandtner might have effected would have accrued to the benefit of the owners of the building; and that he had also hired O'Hea (a draftsman in the employ of the architects) at $5 a day, twice what he had been getting, after they lost confidence in Pole & Schwandtner, to inspect every piece that went into the building and report to them any violation of the building laws. "Although that was really up to the Building Department."

In view of the above revelation, is there any ground for wonderment that the Darlington building fell? Its owner set out to build a twelve-story building, to cost a third of a million dollars, and allotted a little over one-fourth of one per cent. of the cost for architectural plans! Such extravagance as having an architect supervise the construction to see that the plans were actually carried out, he apparently never dreamed of. The matter of safety, in his mind, "was really up to the Building Department," and he relied on that bureau to do the work which it was actually his business to have done and to pay for.

It is of interest in this connection to note the testimony of the Building Department Inspector in whose district the Darlington was located. It was to the effect that at the present time he has to inspect not less than 50 buildings in process of construction, and necessarily could devote to any one of them only a few minutes in a week.

Doubtless one lesson to be drawn from this is that more Building Department inspectors should be employed, sufficient to keep really adequate watch of the process of construction. The more important lesson, in our opinion, however, is the need that buildings should be planned and erected by competent architects and engineers and that owners who try to save a few dollars by putting up buildings without the aid of competent experts are committing a crime against the public safety.

Another example illustrating the results of economizing by dispensing with the services of an architect to supervise work has come to public notice through a Brooklyn court decision. A contractor erected a building for two women and in the course of construction one wall collapsed and fell. He brought suit for the amount due on his contract for the work and put on the stand two Building Department inspectors who, in the words of the court,

had the hardihood to swear to its compliance with the building law. This in face of the collapse of the wall; in the face of the excavating of the so-called "concrete" from under the wall and its production in court, where it was found to be a mixture of ordinary earth and lime; in face of the fact that part of the wall of this building is now standing off the line with no foundation whatever under it.

There was no architect to supervise the work, and the contractors proceeded in entire disregard alike of the contract and specifications and of the Building Law requirements. Concerning the Building Department inspections the Judge said:

Such inspections are a farce, and the people of the city are directly interested in the condemnation of such methods. It is said that these men cover large territories, and that constant supervision and care is impossible. If this is so, their reports are misleading and their so-called inspections had better be abandoned, because the excuse, if accepted, opens the door to abuses which should not exist.

We heartily agree with the Judge that the Building Department inspection ought to be made so efficient as to be a real protection to the public; but in no case ought the owner to rely upon it as in any way relieving him of the necessity of supervising the work himself through his own architects and engineers. Such inspection should be more thorough and more reliable than any Building Department inspection is at the present time or is ever likely to be.

The Building Law and the Building Department were never established for the purpose of enabling owners of real estate to dispense with or economize in expert assistance in building construction. Those who erect buildings or loan money for building operations not planned and supervised by competent professional experts run the risk of serious loss and in addition exhibit a criminal disregard for public safety.

The Pan-American railway scheme is fundamentally resurrected from oblivion by the published report of Mr. Charles M. Pepper, appointed by President Roosevelt a year ago to investigate this old project on behalf of the international committee organized at the Pan-American conference in Mexico two years ago. Commissioner Pepper states that it would require about 4,800 miles of additional construction to complete a through line of railway from New York to Buenos Ayres. This would cost to construct, it is estimated, $150,000,000, allowing an average price for labor of 50 cts. per day, and its efficiency to be 75% of labor in the United States. This would be equivalent to a little over $30,000 per mile. Considering the exceedingly rough mountainous country of Central America and the South American Andes, where the 4,800 miles is located, together with the fact that supplies must be brought from great distances, and the work must be done under the disadvantages incident to the climate in the vicinity of the equator, our readers can form their own judgment as to the probable relation between the estimated and the actual cost.

The most useful part of Commissioner Pepper's report is that in which he calls attention to the general activity, present and prospective, in South American railway construction. The Pan-American railway for through traffic is an iridescent dream. If it were completed and in operation today, the through traffic over it would not pay the interest on the cost of the ties; but a considerable portion of the line is probably destined to be built, not for through traffic, but for local traffic, to furnish transportation facilities which are now almost wholly lacking.

Among the most notable South American railway enterprises now in prospect are the completion of the transcontinental railway from Valparaiso to Buenos Ayres, for which work Chili has just guaranteed 5% interest for 20 years on an expenditure of $7,500,000, to tunnel under the main range of the Andes. The treaty between Bolivia and Brazil recently concluded also furnishes the former country $10,000,000, which is to be applied to railway construction. Brazil, on its part, has also agreed to build within four years the long-deferred railway from Santa Antonio around the Madeira falls to the Mamore. This is the enterprise which was undertaken with disastrous results by a party of American engineers and contractors in 1878.

The fifth annual convention of the American Railway Engineering and Maintenance of Way Association, at Chicago last week showed that this young and vigorous technical association has lost nothing of the active interest and enthusiasm which have marked it since its beginning. The convention of 1904 was more successful than that of 1903 so far as dealing with the reports of the committees is concerned, yet it showed that the Association has still much opportunity to improve in the conduct of its proceedings. At the meeting of 1903, all but one of the 15 committees had reports, but only 6 out of these 14 reports were considered at all, and the discussion of four of these occupied nearly the entire time of the convention. At the meeting held last week, all but one of the 14 committees presented reports, and 11 of these were discussed by the convention, only two being read by title for lack of time. A number of written discussions were printed in a pamphlet for the meeting, but the absence of active oral discussion on technical matters, and the tendency to extend discussions on matters of very minor importance were rather marked features of the meeting.

Much time was consumed in the discussion of the wording of the definitions accompanying several of the reports. These definitions are in

some cases of importance, but not every man or every committee can prepare definitions which will be clear, concise and authoritative. On the other hand many of the definitions were of trivial importance, and still more were unsatisfactory in their wording. A general discussion does not always improve matters of this kind, and the definitions still remain largely indefinite and inconsistent, and in some cases inaccurate. At an annual meeting of busy railway officers the time devoted to discussing the definitions of words might have been spent to better advantage in discussing some of the important technical matters in the reports. It must be said that the only discussions of really large technical importance were those following the presentation of the reports of the committees on rails and masonry. The time wasted over "definitions" was largely responsible for this, and it might be a good plan to omit this particular feature from the reports next year.

The reports on rails was the most significant of all those presented at the convention above noted, and indicated a strong desire on the part of railway engineers to take some steps which will result in securing rails of a better quality than those which have been furnished within the past few years. The general dissatisfaction with the modern steel rails, except those made under special conditions, is well known; and it has also been stated that in some cases rail mills have declined to consider contracts where rails were to be made to the engineers' specifications. The committee included both engineers and rail mill representatives, but these conflicting interests could not harmonize to the extent of agreeing upon all the clauses of the specifications. The most important difference was in the drop-test requirements, the engineers submitting a clause calling for a drop test of every blow of steel, while the mill men submitted an alternative clause providing this test for only one out of every five blows. The mill men claimed that the present practice was satisfactory and that the increased severity of the engineers' specifications would only delay and hamper the work without producing any good results. But the remarks made by the engineers, as noted in the report of the proceedings elsewhere, went very strongly to show that the rails now furnished are very generally of poor quality, unsatisfactory and uneconomical. It is of vital importance that something should be done to remedy these conditions, and it is for this purpose that the increased drop tests are specified. The Association took a rather notable step in adopting the specifications with this rigid requirement of a drop test for rails from every blow of steel, and it remains now to be seen how well this can be enforced and what will be the result in the character of the rails produced.

CONCERNING THE FALL OF THE DARLINGTON BUILDING.

The great and important lesson that the recent collapse of the Darlington Building, in New York city, directly teaches is the need of honesty in engineering work. Whether it be the erection of a bridge or a building, the planning of a railway or a sewer, or the building of a dam or a standpipe, success depends upon conscientious care in dealing with Nature and her laws.

This is particularly true of the work done by the civil engineer. A machine which is poorly designed or carelessly built may yet be serviceable, though its power be smaller or its lift shorter than if it had been more nearly perfect. But civil engineering works nearly always involve more categorical limits, with success on one side of the line and failure on the other. Manipulation and method of operation count for little in making a storage reservoir safe against a destructive break, and the limiting condition is not the matter of greater or less economic return, but the question of safety or danger. Successful work involves a thorough recognition of those limits. Nor can the engineer bury his mistakes and carelessness, for not infrequently they bring ruin to himself as well as to the innocent victims whom the failure of his work involves. More than that, they tend to reduce the usefulness of the entire engineering profession to the world by impairing confidence in its ability and in the reliability of its work.

Of course, every accident to an engineering work, whether it be a "preventable" one or not, has some measure of value, since it tells of dangers not before known, of unconsidered conditions, or of precautions hitherto deemed unnecessary. In those cases which are strictly inexcusable, a failure generally has no other value than merely to serve as an object lesson of the results of neglecting the rules which govern safety. In such cases the redeeming value of the "accident" is least in amount, and there is little to weigh against its deplorable consequences.

The Darlington collapse is a case of this latter kind. It tells engineers nothing which they did not know equally well before. It was simply a case of entire blindness on the part of those in charge to the importance of proper engineering design, persistent efforts by them to cheapen the work without regard to safety; repeated violation of the Building Law, and general carelessness and dishonesty in all parts of the work. It is the story of a costly and important structure built without engineer, without a supervising architect, in short without the assistance or supervision of any competent and responsible person.

The history of the case, as it has developed up to the present from the testimony given before the Coroner's jury, is briefly as follows: A number of men with no knowledge of building or engineering organized a company to engage in real-estate and building operations. They secured a plot of ground in a location favorable for the erection of an apartment hotel, and engaged a firm of architects to prepare plans and secure building permits for a structure to fit the lot, and to cost about $350,000. The company worked purely on speculation, intending to sell the building at a profit as soon as possible after its completion. The ornamental features of the building were naturally of the first importance to the owners. The compensation of the architects was set at $1,200, a very small fraction of that provided for in the code of minimum fees established by the American Institute of Architects,* another condition distinctly unfavorable to good design. It was testified that neither of the members of the firm of architects was a civil engineer, nor was any one of their assistants.

Under the plans thus secured, tenders were asked for the various kinds of work involved in building the structure, that is, ironwork, brickwork, floors and fireproofing, plumbing, etc. The head of the owning company, after receiving the bids, had new iron-plans prepared, with lighter floor-construction so as to reduce the cost. These revised plans were, upon request, signed by the architects, "in order to get them before the building department," although the architects had had nothing to do with preparing these plans and admittedly did not approve of them. However, these revised plans were disapproved by the department. Yet the contract was signed, and the contractor, with the knowledge of the owner, prepared a third set of plans. Meanwhile the construction of the building was begun. The evidence tends to show that the actual construction of the ironwork proceeded under this last set of plans, plans which had not been approved.† The evidence tends to show that the owner knew that the construction was proceeding on unapproved plans; whether the contractor knew this is not clear. He testified that the owner deliberately led him to believe that the second set of plans, on which the third set was based, had been so approved. The iron contractors, it may be noted, had only recently begun business, and the active member of the firm was a former ironworker.

The construction of the iron framework of the building was begun in December, 1903, and at the time of the collapse had progressed to the tenth floor, three stories remaining to be added. The execution of the work was marked by numerous objections on the part of the municipal building department, for violations of various regulations. One such objection related to insufficient provision of tie-rods, another to improper and inadequate bolting of the connections in the beamwork and between the beams and the cast-iron columns, another to the fact that the ironwork was carried up too far in advance of the floors and walls, etc. The owners and the contractor paid little attention to these objections, and it appears that there is no adequate provision of law in the city of New York to enable the building department to stop work summarily under such conditions.

The organization under which the construction work was done was about as follows: the ironwork was in charge of a contractor's foreman who had had a number of years' experience in erecting ironwork for buildings; the floor concreting, the wall masonry, etc., similarly were in charge of foremen; a relative of one of the owners, a man with no experience in building work, was on the ground as the owners' representative or superintendent; and, finally, a former employee of the architects had been hired by the owners to oversee the masonry and miscellaneous work. The last-mentioned was not charged with inspecting the irowork, and had no familiarity with this class of work; moreover, he testified that he was rheumatic and had never gone higher than the third floor of the building. In short, there was no responsible head to the construction work, and the erection of the framework in particular was carried on at the pleasure of the contractors and without any supervision.

One result of this arrangement was that no temporary diagonal bracing or shoring was put into the building until a week or two before the accident; at that time the framework was found to be out of plumb some 18 ins., and it was jacked back into approximate position by means of rope tackle. It was testified that on various occasions the framework swayed noticeably. Another result of the lack of management in the construction work was that little or no care was exercised in storing building material on the completed tiers. A large amount of cement for the construction of the concrete floors was stored on the fifth floor, where the floor had already been put in. At the time of the collapse a large part of the iron required for the construction of the remaining tiers of framework was piled on the last (tenth) tier. Whether or not this piling of material was the direct cause of the collapse, the absence of any control made it a most ready source of danger.

With such a chaotic condition of affairs in the work, and with entire absence of engineering direction, it is evident that the main reliance for inspection was placed on the building department's inspectors. Indeed, the testimony shows that the owners, who virtually conducted the construction work, had no regard for excellence or adequacy of the work beyond the minimum necessary to secure the approval of the building department. More than this, they were prepared to, and actually did, go ahead in their own manner, in opposition to the demands of the building department whenever they thought that the department was powerless to interfere. This is clear from the fact that they proceeded with the framework under a set of plans which had not been approved; again from the fact that, without notice to or approval by the building department, they substituted a concrete-steel floor construction for the hollow-tile of the original plans. It is clear, moreover, from their attitude toward the building department's inspectors throughout the work. The ironworkers' foreman testified that on a half dozen different occasions he was ordered by the department to stop work on the iron frame, and that in each case the owner had told him to go ahead without regard to those orders.

That such a method of conducting important work violates every principle of good practice, and warrants severest condemnation, will be generally agreed. But to show more convincingly the direct danger which resulted from this method in the case of the Darlington, we have only to note an instance of the manner in which the building department conducted its work. The inspector of ironwork on the Darlington Building had a territory of some two square miles, in which much building was in progress. He was

*See Eng. News, Jan. 28, 1904, p. 88.

†From this set of plans the typical floor plan shown in our issue of March 10 was sketched. The examples of column sizes given in connection therewith were from the original plans of the architects, which appear to have been retained.

able to visit and "inspect" each building for only a few minutes each week. He found that the material used in the Darlington was of fair quality, but up to the time of the collapse he did not know that the framework was not in accordance with the approved plans on file with the department. Yet under the method pursued by the owners and the iron contractor, the whole burden of ensuring adequate construction was placed on this inspection.

What is perhaps most striking and incomprehensible in the history of the case is that it was possible for a structure of this kind to be erected well along toward completion, in total disregard of the laws and regulations governing building construction, in the largest city of North America, a city provided with a comprehensive and detailed code of building laws. It is a serious reflection upon the ability of the municipality to enforce its laws that the conditions leading up to the collapse were able to exist. The wholly inadequate nature of the field-inspection by which a large part of the building law must be enforced has been already shown. Even that inspection, however, brought forth numerous evidences of flagrant violation of the law, each being duly reported to the department. But in the face of the violations no effective action was taken to remedy the infractions or punish the offenders. Nothing was done beyond serving notice of the violation upon the parties concerned. It is claimed that no satisfactory means exists and that the department has not sufficient power to compel obedience to the laws; that when plans are once approved and permits issued for a building, the work cannot be stopped or altered except by an awkward, slow and inefficient court procedure. If this be true, means should at once be devised to invest the department with more effective powers, or otherwise to enable the city to enforce its building laws, and even beyond the written laws to secure safe construction.

Besides the general considerations discussed above, there are certain specific technical questions requiring attention. One of these, concerning the practice of loading the finished and partly finished floors of buildings during erection with construction material, was emphasized in these columns only a month ago (in our issue of Feb. 18, 1904) on the occasion of a small floor-failure in a Pennsylvania city. In that case a floor, finished but only partly set, had been used as a convenient storage platform and heavily loaded. The floor in question was a tile floor (with vertical joints). Precisely similar failures of concrete floors have occurred. The present case of the Darlington suggests that the iron framing itself may be endangered by such overloading. Though the precise origin of the failure in the Darlington Building may never be determined, there is every reason to believe that the storing of ironwork and cement on the floors had an important bearing on the failure. The connections of the framing, particularly in bolted work as is always practiced when cast-iron columns are used, have no such excess of strength as will enable them to carry concentrated loads piled over the beams or around the columns in amounts far exceeding the bending strength of the beams themselves.

This matter of overloading, again, is only a part of the subject of erection stresses. The latter have been given little thought in building work, though carefully considered in bridge erection. Two divisions of the subject are concerned: (1) The stresses due to external loading in excess of that for which the structure is designed, and (2) the stresses arising from structural differences between the partly finished and the completed work. The stresses in the first-named division are obvious, and they can be readily allowed for (or avoided if excessive) provided that they receive fair consideration. It is this latter point that requires emphasis: the erection loading *must* be given intelligent consideration in all building work. Under present conditions, even the very evident loads of stored material receive little thought, as may be concluded from the repeated accidents due to such loading. In addition to the vertical loading from stored material there are other serious loads, such as those from the erection derricks, etc. Transverse loading, from wind, from derrick guyropes and sometimes hoisting ropes, is also present, and its importance is increased by the fact that the iron framework of certain types of building is ill-adapted to resist large transverse loads. This fact is closely connected with the other division of erection-stresses; those due to structural characteristics of the skeleton frame standing alone.

Steel skeleton or cage construction in its complete development gives us a rigid steel framework connected and braced like a bridge in all directions, carrying walls, floors and finish merely as so much clothing, and able to safely bear all loads which come on either the completed building or the framework alone. Structures of the "office-building" type are practically all of this kind. But very many other buildings, from five or six-story warehouses and stores to twelve- (and in at least one case seventen-) story apartment buildings, are radically different in structural respects, though masquerading under the same general name of "skeleton" or "steel-frame" construction. They have floor beams and girders of steel, columns of either steel or cast-iron designed for vertical, central, loading only; they are provided with no bracing, and the connections between beams and columns are unfitted to resist any calculable bending or twisting moments. In such buildings the walls and floors give lateral strength and stiffness to the structure, while vertical loads are carried by the frame. Evidently this is quite different from the condition in an office-building structure, both after and during erection. Of course, it is known that when the walls are in place and firmly set, they supply sufficient lateral resistance, though the amount of this resistance can not be calculated, especially when the wall is pierced by windows in every panel. Before the walls are built, however (usually the frame is nearly completed before the masonry is begun), the frame must depend for strength against lateral forces on the unknown but certainly small rigidity of its joints, together with the effect of such temporary diagonal braces as may be put in during erection.

It is in this state that the frame must resist vertical and lateral "erection" loading which may be large in amount. The framework of the Darlington, which was of the type referred to, proved to be anything but rigid against this loading. The framework often swayed perceptibly, as testified, and on one occasion it leaned over from six inches to two feet out of plumb. On that occasion the frame was pulled back to place and the incident forgotten. Yet it is anything but certain that "working" of this kind in a lofty framework is harmless. Rather should it be considered a most serious danger. It implies a straining of all members and connections of the frame, serious enough in a frame made wholly of soft steel, but doubly serious when the columns are of cast iron, the connections are flanges and brackets of cast iron, and the connecting members are loose-fitting bolts. Similar "working" during erection undoubtedly occurs in nearly every structure of the same type. Its amount and influence are probably small when the building is low and wide, but must increase very rapidly as the ratio of height to width increases.

It may be true that all injurious effects due to insufficient rigidity of the framework during erection can be wholly avoided by careful attention to the matter of temporary bracing. Certain, it is, however, that only in few cases is anything approaching sufficient bracing provided. Engineering supervision is often absent, as in the case of the Darlington, and the individual contractors and foremen are interested only in speedy and cheap erection. Reliance on perfect provision of bracing, when the danger of unbraced construction rapidly increases as the height of the building increases, has the defect of giving no margin of safety to cover imperfect or careless work. On this account sound engineering would seem to require that the use of any type of construction which involves such dangers be limited to buildings of moderate height and reasonable ratio of height to width. Limits of this kind may, sooner or later, become part of every good code of building laws. The engineer, however, should not find his specifications and his code of good practice in a legal instrument like the building law, but should be in advance of the law just as much as personal integrity is in advance of the limits set by the penal code.

We referred above to steel columns usually with cast iron, because the latter are now the only source of objectionable construction in building framework. It is true that cast-iron columns do not lend themselves to satisfactory details and virtually necessitate connections which produce eccentric loading and which have no appreciable strength or rigidity against forces tending to distort the framework. It is equally true that steel columns, when sufficiently heavy and of suitable shape, lend themselves readily to satisfactory and rigid connections, giving approximately central loading on the columns. But when steel columns are used in lightly-loaded structures of the type referred to, they are only too frequently prostituted to cheap detailing. Bracket connections are used which are not appreciably better than those of cast-iron columns; sizes and shapes of columns are used which make a central or rigid connection impossible; bracing which might so easily be provided either by diagonals or by knee-braced connections is neglected as being superfluous; and a structure results which, except for the greater insensibility of steel to abuse, is hardly better than if cast-iron column construction had been used. All that has been said above applies to building frames designed in this manner equally with those having cast-iron columns. There is this difference, a difference which good practice always takes advantage of: with steel columns a wholly satisfactory design is possible in all cases, with only slight additional expense over that required for poor design, while the limitations of cast-iron columns are firmly fixed.

LETTERS TO THE EDITOR.

Slow De-Compression is the Best Way to Prevent "The Bends."

Sir: I wish to add my hearty approval of your simple, but effective, prophylactic treatment of that dreaded caisson-disease, "The bends." A somewhat careful study of this matter, with experiments in pneumatic work, convinces me that it is the coming out of the high to normal or lower pressure that hurts and kills. Reduce pressure slowly, and give the highly compressed air in the body time to come to the lower pressure, and don't hurry coming out of the air chamber, and there will be few, if any, fatalities in pneumatic work.

"Slow reduction of pressure is the best preventative." Make the lock-tender obey that rule and danger from "the bends" will be reduced to a minimum.

James P. Nelson.

Richmond, Va., March 15, 1904.

Some Remarkable Records in Taking Soundings Through Ice on Lake Superior.

Sir: In your issue of Feb. 18, 1904, under the heading "Notes and Queries," I notice a request by "L. E., Chicago, Ill.," for information regarding an appliance for boring holes through ice for the purpose of taking soundings.

I have had charge of survey parties for the past six winters in which such machines have been used and records kept of their efficiency. These records are made public in the annual report of the Chief of Engineers, U. S. A. The latest report on the subject being in Appendix K. K. of the annual report upon the "Improvement of Rivers and Harbors on Lake Superior," in charge of Major Lansing H. Beach and Capt. D. D. Gaillard, for the year 1903, from which I quote the following:

Some interesting figures relating to this work are given herewith. A total of 124,730 soundings were taken between Dec. 4, 1902, and March 13, 1903. Thickness of ice, 4 to 48 ins.; average, 21 ins. Total thickness of ice cut through, about 40½ miles. Two parties were employed, each equipped with an ice-boring machine and sounding appliances.

The ice-boring machines are of the type built originally by James Stracham in 1892, and first used in that year on the Hay Lake survey, St. Mary's River, under direction of Gen. O. M. Poe. It is described in the Annual Report of the Chief of Engineers, for 1893, Part IV., p. 2904. An improvement in the auger was added by this office. The machine will cut a 2½-in. hole through 2 ft. of solid ice in about five seconds.

Under favorable conditions each party could take 300 soundings per hour through ice 24 ins. thick, in 22 ft. of water, spaced 10 ft. by 50 ft. The best record for one day of eight hours was 2,749 soundings in ice 13 ins. thick and 22 ft. of water.

The cost of these soundings was 3 cts. each for field work alone. The soundings were laid out on the ice by transit and steel tape with accuracy and rapidity.

Respectfully yours,

G. A. Taylor.
U. S. Junior Engineer.

U. S. Engineer's Office, Duluth, Minn., March 12, 1904.

Log. Functions of Small Angles, and the Construction of a Parabola.

Sir: The method for finding the trigonometric functions of small angles given in Engineering News for Jan. 28 can hardly be called new, as it is given in nearly all of the standard 6 or 7-place tables in common use. It is used in the 7-place tables of Bruhns, Schroen, Callet and Vega, and in the 6-place tables of Bremiker. Of tables published in the United States, I notice that the method is given in Geo. W. Jones' 6-place tables and in the 5-place tables in Crockett's Trigonometry. The method is due to Delambre. The values of log sin A — log A and log tan A — log A are denoted in the tables by S and T.

Another method due to Maskelyne is also convenient. For small angles log sin a = log a + ⅓ log cos a, approximately. Here a = arc to radius unity = n × arc 1″ = n sin 1″ approx. Therefore, we may write the formula

log sin a = log n + log sin 1″ + ⅓ log cos a.

Example: a = 0° 1′ 23.5″ = 83.5″

log 83.5 = 1.9216865

log sin 1″ = 4.6855749 — 10

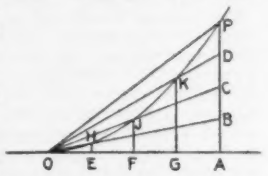
6.6072614 — 10

In this case ⅓ log cos 0° 1′ 23.5″ = 0 nearly.

In applying this formula, one must, of course, subtract 10 from the tabular log cos a before dividing by 3.

For further information see Bowser's Trigonometry, p. 224, or the very extensive English work, Hobson's Plane Trigonometry, p. 147.

In Engineering News for Jan. 21 is given a method for constructing a parabola when the tangent at the vertex, the vertex and another point are given. The following method is also simple:



P is the point on the curve. O is the vertex. Divide A P and O A into the same number of equal parts. Draw lines from O to the points of division of A P and perpendiculars to O A through the points of division. Their intersections H, J, K, will be points on the parabola.

Yours truly,

E. B. Escott.

Ann Arbor, Mich., March 2, 1904.

The Work of the Corps of Engineers.

Sir: An editorial on page 152 of the Feb. 18 issue of your valuable journal on the subject of the increase of the Corps of Engineers of the Army touches upon a matter of much general interest.

The quoted portion of General Gillespie's last annual report wherein are given the reasons why an increase of the Corps is absolutely necessary for the benefit of the public service, states the situation very clearly. The Corps has more work assigned to it by law than it can possibly look after with the care and attention with which public work should be directed and any private work is directed. In the discharge of its many and varied duties in the past the Corps has acquitted itself with fealty to the obligations of and with honor to the service. The fact that more work is constantly entrusted to it is the best testimonial to the character of the work done in the past.

Having observed these facts the writer wishes to ask whether there is not another solution of the problem how to prevent the overloading of the Engineer Corps with additional duties—duties which from the nature, intent and purposes of the Army seem not rightly placed by law. Why men of military training, schooled at government expense at a military academy, are turned from their true profession? Is there no organization or organizations today to take over these works of the river and harbor improvement, the care and improvement of national parks, the survey of the Great Lakes, the municipal engineering work of the national capital—works of a purely civil character—and thus relieve the Corps of Engineers of encumbering duties to the betterment of the military service?

The Department of Commerce and Labor was created a few years ago to relieve other departments or bureaus of work which was not pertinent to the purpose for which these departments were organized. Would not the Department of Commerce, which has already taken over the Light-House Establishment, be a proper body to exercise control over rivers and harbors? The Department of the Interior maintains the Geological Survey, whose splendid work is familiar to all, and which body is now proceeding with the execution of the provisions of the Reclamation Act, the building of the great irrigation work in the West. Could not the Department of Commerce, with the Civil Service to supply engineers of long experience in this particular work, take over the care of the rivers and harbors with propriety and fitness, and relieve the congestion of work in the War Department?

"Commerce."

March 15, 1904.

Determining Superelevation on Curves.

Sir: Your issue of Feb. 18 contains an article by Prof. W. D. Taylor concerning some common inaccuracies in engineering practice. While it seems hardly probable that errors like the one mentioned in connection with the volume of stone piers are of common occurrence, it is certainly true that theory and practice should be in accord in a problem like the superelevation of the outer rail.

In the formula $e = \frac{G\,v^2}{32.16\,R}$, G is usually taken as the distance between rail centers or 4 ft. 8.5 ins. plus the width of a rail head. This distance must vary with the rail section and often with the degree of curve, hence no universal coefficient can be found for $v^2 D$. However, from the above formula, $\frac{e}{G}$ will always be the sine of the angle between the horizontal and a line joining any corresponding points on inner and outer rails; and it only remains to design a level board that shall be level on top when resting on properly elevated rails. The board in common use and sketched by Prof. Taylor is faulty in that the tops of the notches are parallel to the edge of the board, whereas they should make known angles with it. The pattern for the board is perhaps most easily made as follows: The rail section and gage are laid off to full scale and a line is drawn between the inner upper corner of the rails. Above one of these corners the values of e are laid off as computed with G as 4 ft. 8.5 ins. and lines are drawn to the opposite corner from each point marked on the vertical. A strip of tracing cloth, 1 ft. wide and as long as the board is to be, is placed over the first drawing, so that its edge is parallel successively to each of the radiating lines through the rail corner; and the top and inside of both rail heads are traced. From this tracing a templet is made as a pattern for all level boards issued to track men.

In the sketch the notches are 1 in. deep and 3 ins. long on the outside end; a′ b′ and c′ d′ are respectively on lines a b and c d produced.

Very respectfully, John P. Brooks.

State College of Kentucky, Lexington, Ky., Feb. 26, 1904.

Sir: I have read with much interest the article by Prof. W. D. Taylor in Engineering News of Feb. 18, 1904, on the above subject and most heartily agree with him as to the necessity "of engineers using plain, well-considered and correct terminology."

If there is any profession where exactness, not only in expression, but in all calculations is necessary, it surely is in that of engineering, where the expenditure of millions of dollars is dependent upon the exact terminology of the engineer's specifications, and the safety of the traveling public depends upon the exact theoretical correctness of his formulas and calculations for various structures.

Looseness of thought and terminology is nowhere more common than in specifications for the various items of construction, especially those for grading; and like all looseness of agreements it is the fruitful source of litigation, to avoid which engineers are often induced to classify according to the actual cost of the work (whether done skillfully or not) and not, as they should, according to certain definite and well defined rules, understood and agreed upon at the signing of the contract.

Indeed, I have known an engineer to give instructions to his subordinates to keep the monthly estimates down as low as possible. He would then wait until the contractors made their claims, either by suit or otherwise, when he would begin to "dicker" with the sub-contractors and settle with them by "doctoring" the estimates just enough to save the company a suit. Such a practice is, in my opinion, unworthy of the profession and unfair to the contractors. It puts the skillful, intelligent and energetic contractor on the same footing as the shiftless, unskilled and lazy, provided the latter has sufficient skill in diplomacy to "fix" the engineer.

I will turn now to Professor Taylor's use of the superelevation formula as an example of inaccurate approximation, and it seems to me the professor is in error.

Is not the general practice of representing G as 4 ft. 8½ ins., or the distance between gage planes, the correct one? By using such, we use a standard which is known and accepted by every one, while 4.9 ft. may be the correct constant for a certain standard of rail section and incorrect for another. If we have a table of differences of elevations calculated by the constant 4 ft. 8½ ins., we can of course get the proper difference in elevations for any other constant, for the elevations vary as the constants, as will be readily seen from the following:

Let G = the new constant and x = the proper elevation therefor. Then using the formula $e = \frac{G\,v^2}{R\,1.25}$, which is directly derived from $e = \frac{G\,v^2}{R\,32.17}$ and is much simpler (G being gage in feet and v the velocity in miles per hour), we have $e : x :: \frac{G\,v^2}{R\,1.25} : \frac{G_1\,v^2}{R\,1.25}$ or $\frac{e\,G_1\,v^2}{R\,1.25} = \frac{x\,G\,v^2}{R\,1.25}$

$\therefore x = \frac{e\,G_1\,v^2 \times R\,1.25}{G\,v^2 \times R\,1.25}$, or equating and canceling $x = \frac{e\,G_1}{G}$. This gives for a 60 miles per hour speed on a 2° curve a value of e of 4⅜ ins., with G = 4 ft. 8½ ins., or x = 4 and 15-16 ins., with G_1 = 4.9 ft. and x = 10 and 1-16 ins., with G_1 = 10 ft.

Again, as most railways now use ballast and as many adopt the rule (which the writer thinks much the best practice) of depressing the inner rail and elevating the outer just half the calculated elevations, given by this formula, grade stakes for the proper superelevations are generally given every 30 ft., longitudinally, and 10 ft. apart, the elevations for which can be calculated from the table with the 4 ft. 8½ ins. constant. In using the track gage the width of the straight surface of the ball, or head, of the standard rail used should be measured and the track foreman instructed as to the proper superelevation, according to the kind of gage he uses.

Wm. P. Watson, M. Am. Soc. C. E.

P. O. Box 131, Columbia, Pa., March 2, 1904.

(Without taking issue with any of our correspondents, we may perhaps call attention to the fact that the superelevation of a rail on a curve is at best such a rough approximation that undue refinement in its computation, such as corrections for the width of different size rail heads, would be practically a waste of time. We need only recall the fact that the theoretical superelevation to balance centrifugal force would vary with the speed of the train, so that the superelevation on a curve is really correct only for trains of one particular speed. As a mater of fact, the superelevation chosen is usually a compromise between the demands of passenger service and of freight service, and considerable variation in superelevation allowance appears to exist without any evil results.

Proof of the above letter was submitted to Prof Taylor, and his reply is appended.—Ed.)

Sir: No matter whether the writer, or Mr. Watson is right as to the proper value of G in the formulas above, the diverse positions taken by the two writers illustrates the truth of the contention made in the writer's original article.

Mr. Brooks says: "G is usually taken as the distance between rail centers or 4 ft. 8.5 ins. plus the width of a rail head."

Mr. Watson says: "Is not the general practice of representing G as 4 ft. 8½ ins., or the distance between gage planes, the correct one?"

The matter is hardly worth further argument.

As to the remark made by Mr. Brooks: "It seems hardly probable that errors like the one mentioned in connection with the volume of stone piers are of common occurrence" the writer will say that not a great while ago he had an assistant in his teaching at the University of Wisconsin who had been an assistant engineer on the Pennsylvania R. R. This assistant chose to attend the writer's classes in elementary railroad engineering. In a certain recitation the writer had tried to show his class in a practical way when they should and when they should not use the average end area method in calculating earthwork. Perhaps it would be nearer the truth to say that he was trying to show the class how the work should be cross-sectioned so as to permit of the average end area method being used without material error. After the class the assistant said: "You have shown me that there have been some overpaid contractors on the Pennsylvania R. R."

W. D. Taylor.

Madison, Wis., March 12, 1904.

A Neat Detail for Hydraulic Elevator Plungers.

Sir: While on a tour of inspection preparatory to making a report on existing conditions for one of my clients recently, my attention was called to an exceptionally attractive looking elevator pit. The pit was of ordinary brick construction, whitewashed, and was as clean and dry as a hardwood parlor floor. Upon close examination I found out that a plunger lubricator was responsible for this cleanliness. This lubricator prevented leaking of water and the objectionable feature of elevators of this class, the dripping of grease and oil. Consequently, when these objectionable features are removed the pit can be kept clean and when whitewashed looks neat and attractive.

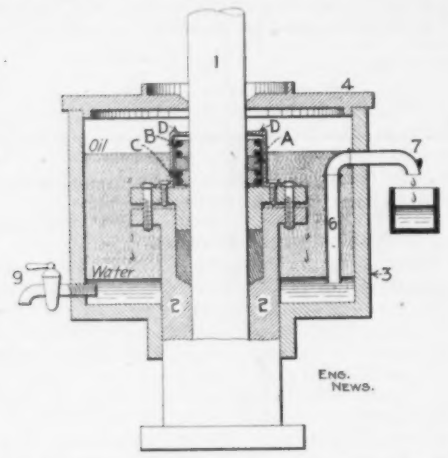
Realizing that as this is a new device and thoroughly practical, it might be well to bring a short description, with sketch, before your readers for their attention.

The sketch represents the plunger of a hydraulic elevator with stuffing box in section. The casings were built in semicircular sections bolted together around the stuffing box, the joints being caulked with "Smooth-on," which rapidly hardens and becomes like iron. The outer casing, 3, is a liquid-tight receiver, which is provided with a

cover, 4, leaving an opening through which the plunger rod, 1, passes.

Extending nearly to the bottom of the receiver is tube 6, connected at the upper end to a spout, 7. The receiver may also have a draw-off cock, 9.

Ring A is a solid ring and fits the plunger loosely. B and C are adjustable, kept in place by the springs and act as wipers both on the upward and downward strokes of plunger, allowing only sufficient oil to adhere to the plunger to properly lubricate the same and keep the packing pliable and water repellant. D. D. are attachments



Section Through Stuffing Box of Hydraulic Elevator Plunger, Showing Lubricating Chamber.

which regulate the space between the rings and are adjustable. On the upward stroke the ring B is lifted by the plunger, allowing the oil to be admitted. The opening is closed on the downward stroke, preventing the admission of excess oil.

The operation is as follows:

Water is first placed in the receiver so as to stand above the end of the tube 6. The receiver is then filled with oil to the bottom of ring B. It is obvious that the plunger will be efficiently lubricated and that any drops of water which may leak past the stuffing box will fall through the oil to the water level at the bottom of the receiver and be ejected through the tube 6. No oil can thus escape. This lubricator positively prevents scoring and pitting of plunger, requires less power, saves oil, prevents the leaking of water and increases the life of the packing, and thus saves labor and attention.

These advantages recommend its use on all plunger elevators, especially those of the high speed passenger plunger type. Respectfully yours,

Edward Van Winkle,
Consulting Engineer, 160 Fifth Ave., New York City.

Effect of the Baltimore Fire on the Continental Trust Building.

Sir: I visited Baltimore soon after the conflagration and looked over the buildings, more especially the Continental Trust Building, which was designed by D. H. Burnham & Co., and completed during the spring of 1901.

I found that the steel frame was entirely intact except a few of the spandrel sections of the court. In the court cast-iron mullions, which were not fireproofed, were connected to the spandrel beams and they (the mullions) warped and pulled the steel beams so much out of place that the fireproof brick and terra cotta had fallen off and left the steel exposed in such a shape that much of it will have to be removed. This does not apply to the spandrel girders, but only to the light beams supporting the outside edges of the spandrels.

I examined many of the interior columns and found that they had not been heated enough to effect the paint, and the tile around the columns was in perfect condition. This was also the case with most of the floor arches, with the exception of the ceiling of corridors having marble finish. This marble finish had been supported from the soffits of the tile arches by means of holes drilled through the soffits and hook bolts inserted in these holes, and the heating and warping of the marble had pulled the lower side of the tile arches off, leaving the vertical webs exposed, but even here the steel was not exposed enough to be damaged.

The granite exterior wall covering had spalled off where the heat had struck the corners around the window openings, but the main wall surface was in good shape. Some of the terra cotta window sills and heads were somewhat chipped, but whether from heat or from being struck by falling material is hard to determine. Generally speaking, this material was in fair shape, except, as before stated, in the rear court.

My conclusion is, not one from this building but from other buildings which I saw, that tile is a good protection for steel, and in this fire showed that it is all that has been expected of it.

The windows of our high buildings are the vulnerable points in an attack from fire from the outside, and the future efforts of architects should be to protect in a more efficient manner this point either by the use of wire glass in windows or shutters. Cast-iron mullions should not be used, and if used should not be connected with the steel framing. Metal sash and frames would naturally recommend themselves.

In order to reduce the amount of combustible material inside of a building wooden floors should not be used. Metal door frames and finish should be substituted for wood, as well as metal furniture for wooden furniture, all of which would be a step in the right direction for fireproof buildings, but whether or not it is practicable at this time is another question. Yours very truly,

J. G. Glaver,
Chief Engineer of Construction, D. H. Burnham & Co.
The Rookery, Chicago, Ill., March 17, 1904.

The Penalty Clause in Engineering Contracts.

Sir: For the benefit of those young engineers who read Mr. Valentine Ball's article, "The Penalty Clause in Engineering Contracts" in "The Engineering Magazine" for February, I offer these suggestions on the preparation and interpretation of forfeiture contracts based on a recent practical experience in the courts where the contractor sued to recover a lump sum withheld for failure to complete on time in accordance with a stipulation for liquidated damages in a contract, which, as chief engineer for the defendant company, I prepared and interpreted. This case having been settled favorably for the defendant during the trial without a decision by the court, has no value for reference, except to show in a practical way that the employer's interests were protected by a contract stipulating a lump sum as liquidated damages for non-completion by a specified day.

It is not my intention to criticize the article referred to, which doubtless shows what has from time to time been regarded as the law; but I hope to relieve the engineer who reads the article from some of the doubts by which he may be smothered by the conflicting decisions cited, and encourage him to have more confidence by a few practical hints, which, while their ultimate value may be questioned by lawyers, can hardly fail, if followed, to strengthen the position of the employer and make the engineer's contract and practice least vulnerable when subjected to the examination of lawyers and courts.

The best expression of the law on this subject known to me is in the case of The Sun Printing & Publishing Company vs. Moore, October, 1901. 183d. U. S. Every engineer should read this opinion so far as it applies to penalties and liquidated damages.

In preparing a contract avoid the use of the words "penalty" and "forfeit" and fix the "liquidated damages" at an amount no greater than the maximum actual damages which you can conceive as likely to accrue from the contractor's failure. Go somewhat into detail as to what loss, expense and damage the sum or sums named as "liquidated damages" are in compensation for. While the words "penalty" and "forfeit" do not necessarily render invalid your stipulation, they may impair it; and it will only remain binding because the court holds that the sum so denominated may in fact have been assumed to be the measure of damages. It is certainly better to avoid these terms and establish by the wording of the contract itself a presumption in favor of the idea of a prearranged measure of damages, very easy to do by the use of appropriate descriptive words. The maximum expense, loss and damage probable by the contractor's failure gives the engineer ample opportunity for the protection of the employer's interests, and enables him to stipulate in the contract so large a sum that it will be just as strong an incentive to hurry the contractor as a penalty or forfeiture; and probably even more of a spur, since there is more likelihood of the courts dismissing the penalty or forfeiture as invalid and requiring actual damages to be shown.

It is not necessary in time limit contracts, though frequently so regarded both by engineers and lawyers, to express forfeiture, penalty or liquidated damage stipulations as a per diem or term sum, nor to introduce a reciprocal per diem or term bonus for expedition, on the theory of mutual rewards and punishments. I believe the validity of the stipulation will depend upon its appearance of having been agreed to at the time of making as a reasonable measure of probable damages, and not upon its being mutual or reciprocal. Thus a lump sum for failure to complete a railroad by a certain day is reasonable, if the railroad itself had been promised a bonus of a like sum for its completion by the same day, which it might lose by the contractor's failure. Also, a lump sum reasonably measures damages for loss of seasonable traffic, such as a crop, though the movement of the whole crop could not in any case have been lost by a delay of a single day, or a single week or even a single month in completion. Still, as some day has to be designated for completion and some amount named as compensation for failure to complete, and the damages in such cases are always uncertain and hard to ascertain the courts are almost certain to uphold as binding a stipulation for liquidated damages which appears on its face to have been agreed to, in the belief that it was a reasonable measure of damages. Such a favorable construction of the contract will be made much more certain by enumerating as probable causes of damage one or more of the items upon which such damages may possibly arise by failure to complete as per contract. It is better to name a per diem or term sum in compensation for the loss of the fair rental value of the property while incomplete" than to name a lump sum, on the that such a stipulation may not have the stimulating effect of a lump sum prior to the time limit. It is often advisable to name both a lump sum and a per diem, such a combination being the most reasonable measure of damages which can be assumed. The point is to make these stipulations indicate in themselves that they are for compensation for certain possible losses or damages.

Where the employer has certain duties to perform as a condition precedent to the progress or completion of the work, such as furnishing or delivering materials, etc., a clean explanation in the contract of what constitutes failure by the employer sufficient to warrant an extension of time, and a requirement that the contractor shall make a demand in writing for such materials before he can claim an extension on account of late delivery will generally prove an effective answer to unreasonable claims for extension based on immaterial delays. The contractor should also be required to make extension claims in writing within 30 days of the supposed delay upon which such claim is based.

The engineer's authority with regard to extensions should be fully explained in the contract. Avoid unconsciously waiving a stipulation for a lump sum at the time named for completion. It is safer to advise the contractor in writing that the time limit has expired, the damages have accrued and the sums stipulated are and will be withheld, and express your interpretation of the contract with regard to the final completion of the work, subject to the damages already sustained and charged against the contractor.

The details of this subject are interminable and I shall only add that these stringent provisions should be used only to protect the employer against an indolent or dilatory contractor, and never to crush a willing but unfortunate worker. In the granting or recommending of time extensions the engineer should be as liberal with the contractor as fairness to the employer will permit, and any delay in completion due to the employer should be frankly acknowledged and compensated for by more time.

W. A. Stevenson.
El Paso, Tex., March 15, 1904.

Notes and Queries.

"Engineer" wishes to know what constitutes "gumbo" in earthwork classification, and wherein it differs from common clay.

D. F. L. writes:

I should like to learn through the columns of Engineering News the opinion of the leading engineers who have had experience in concrete construction as to the question of heat generated in the setting of cement, and also their ideas as to when concrete assumes the maximum volume. It is an established fact that a certain amount of heat is generated during the process of setting of cement.

In describing the reinforced concrete footing for retaining walls for the Pennsylvania R. R., we inadvertently neglected to state in our issue of March 17 that the design was prepared by the Reinforced Cement Construction Co., of New York City, Mr. J. O. Ellinger, Engineer.

In the article describing the Yellowstone Park bridge, in our issue of Jan. 14, the author informs us that the structure was built under the patents of the Concrete-Steel Engineering Co., of New York City, and that it was through oversight that this credit was not given in the original paper.

THE CALCULATION OF SINKING FUNDS.

By Peter Mogensen.*

In Engineering News of Oct. 21, 1897, p. 259, is a reprint of an article by the writer on the calculation of sinking fund, originally published in the "Technograph," No. 11.† In Engineering News of Dec. 2, 1897, p. 362, an editorial comparison was made between a formula given in the above article and two other formulas, and the conclusion was reached that the former was the most accurate.

The formula referred to is as follows:

$$\frac{A}{C} = \frac{r^s - 1}{r^{ns} - 1} \text{ or } A = C\,\frac{r^s - 1}{r^{ns} - 1}.$$

*6109 Monroe Ave., Chicago, Ill.
†The "Technograph" is published by the engineering societies of the University of Illinois.

in which

A = annual instalment, the first payable one year after investment, and the last at the end of n years.

C = capital invested.

r = one dollar with half a year's interest added (the interest being compounded semi-annually).

n = number of years from investment to maturity of sinking fund.

This formula will give satisfactory results for all ordinary sinking fund and annuity calculations, but it often happens that a sinking fund must be computed on an entirely different basis, i. e., when the annual instalment is not constant, but varies from year to year at a fixed rate. A sinking fund thus computed might appropriately be provided in the case of an enterprise from which the expected income would be large at the outset, and would decrease to nothing in an assumed number of years—conditions which frequently obtain in mining operations.

As a constant yearly instalment was assumed in the deduction of the above formula, it is of course not applicable in cases where the instalment either increases or decreases, and a modification is required as follows:

$$A = C\,\frac{r^2 - f}{r^{2n} - f^n}$$

where C, r and n are defined as before, but A is now the first instalment and f is a constant by which each annual payment is multiplied to give the one for the succeeding year. The yearly instalment thus varies in geometrical ratio, being A, Af, Af^2, etc., for the 1st, 2d, 3d, etc., year, respectively, and increases or diminishes according as f is greater or less than unity, and this constant must be so chosen as to give the desired variation. When f is equal to unity this formula becomes identical with the one before given.

To illustrate: The first payments required to refund one dollar at the end of 10 years under the conditions assumed in this formula when the interest (r) is 5% per annum and f is 0.8, 1.0 and 1.2 are 16.36, 7.93 and 3.29 cents, respectively.

THE RELATION BETWEEN UNFILTERED WATER AND TYPHOID FEVER AT LORAIN, O.

By C. Arthur Brown.*

Noting the various reports on typhoid fever epidemics in recent issues of Engineering News, the writer feels that the recent experience of Lorain, O., may be of interest to engineers. This city is supplied with water from Lake Erie, the intake being 1,700 ft. off shore. Black River, passing through the city, receives the sewage of Lorain and at a distance of nine miles above, that of Elyria as well. The river enters the lake about a third of a mile to the east of Lorain's intake crib. The flow of the lake is normally to the east and away from the intake, but a change of wind or lake level may cause it to go to the west and to the crib. The sewers of Lorain were constructed in 1892 and typhoid made its appearance very soon. This rose to such a point that the city installed a Jewell mechanical filter plant in 1897. The death rate from typhoid per 100,000 population for the years 1889 to 1902, inclusive, was as follows:

1889	44	1893	183.3	1897	24.4	1900	11.5
1890	20	1894	48.8	1898	21.2	1901	5.5
1891	57	1895	131.6	1899	24.2	1902	26.3
1892	53	1896	83.3				

In 1902 there was some complaint about the filters not being properly operated. There was no expert in charge.

For the first seven months of the year 1903 the death rate from typhoid was zero, not a death occurring. On July 16 the filters were found to be in such a condition that repairs were absolutely necessary. The plant was closed for repairs and the public advised to boil all drinking water. In spite of this the death rate immediately rose and the disease rate went very high. The table below shows the rise and fall. The filters were out of service continuously from July 16 to Sept. 11 and intermittently from Sept. 11 to Nov. 1. For the two months previous to closing down the plant the daily bacterial examinations were unsatisfactory to the writer, but the exact cause was difficult to locate. The monthly rate is figured on a per annum basis. The assumed population was 20,000.

The death rate from typhoid for the month of January of the present year was zero.

1903.	Annual rate, per 100,000 population. Death.	Disease	1903.	Annual rate, per 100,000 population. Death.	Disease
January	0	180	July	0	180
February	0	240	August	180	1,800
March	0	60	September	180	4,020
April	0	0	October	180	2,940
May	0	0	November	180	300
June	0	120	December	60	120

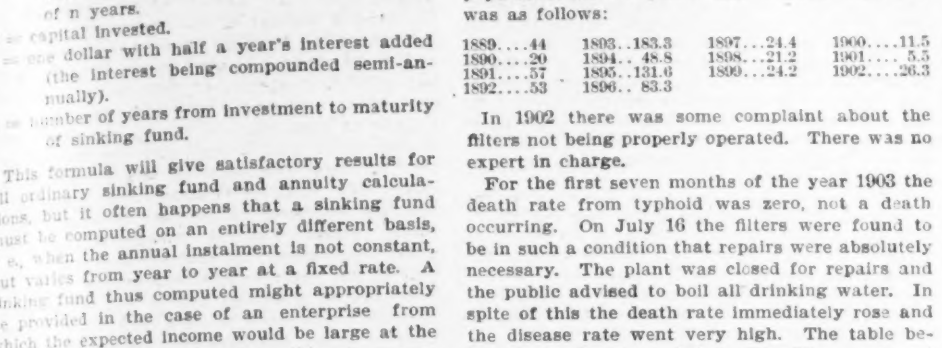


DIAGRAM SHOWING MORTALITY RATE FROM TYPHOID FEVER PER 100,000 POPULATION IN SIX CITIES.

(Figures from Wright's "Statistics of Cities, 1898-1901." Other years from Board of Health reports. Filtration plants were started at Lawrence in September, 1893; at Hamburg in May, 1893; at Lorain in February, 1897; at Albany in August, 1899.)

The fifth annual meeting of the association was held at the Auditorium Hotel, Chicago, March 15, 16 and 17, and was very largely attended. Of the 15 committees, one (Uniform Rules and Organization) has been dropped, and the Committee on Signaling and Interlocking had no report. Of the 13 committee reports issued during the past few months, 11 were taken up and discussed, and two were read by title, but unfortunately much time was practically wasted in discussing the wording of definitions accompanying the various reports. The association devoted itself strictly to business during the three days, six long sessions being held, at all of which there was a full attendance and an active participation in the proceedings. The only entertainment feature was the annual dinner.

At the opening meeting on the morning of March 15, the annual address was read by the President, Mr. Hunter McDonald, Chief Engineer of the Nashville, Chattanooga & St. Louis Ry. He devoted himself mainly to the subject of the work of the association and its committees, and means of improving the methods and quality of this work.

*Superintendent of Filtration, Lorain, O.

ANNUAL CONVENTION OF THE AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION.

The report of the secretary and treasurer showed the following results:

Balance, cash on hand, March, 1903	$3,783
Receipts during the year	8,479
Expenditures during the year	7,336
Balance to credit	1,123
Balance, cash on hand, March, 1904	$1,906
Bills receivable	1,847
Membership at last annual convention	441
Members admitted during the year	61
Members deceased	8
Members withdrawn	12
Members dropped for non-payment of dues	37
Members lost (total)	57
Net increase	4
Membership, March, 1904	445

The following members of the association died during the year: M. Collins, H. C. Draper, J. J. Frey, J. V. Goode, G. W. Gardner, Theo. D. Kline, Geo. S. Morison and R. H. Wight.

After these preliminaries, the regular business of the convention was taken up. Abstracts of several of the committee reports were given in our last issue. The following is a general report of the proceedings.

BUILDINGS.

This committee's report was not considered at the convention of 1903, owing to lack of time, and was reprinted (with some few changes) for the convention of 1904. It belongs to that class of reports which is compiled largely from replies to circular letters, and its main subject was the accommodation provided in passenger stations for towns of 10,000 to 15,000 inhabitants. A number of plans were submitted to the committee, and its report gives a table of the space allotted to the various departments in individual stations. The average is 1,160 ft. for waiting rooms, 186 sq. ft. for toilet rooms, 433 sq. ft. for baggage rooms, and 218 sq. ft .for ticket offices. A form of contract for the construction of station buildings was given in the report, with some notes also on specifications. The report was adopted without discussion.

TIES.

This committee's report was also passed over at the convention of 1903, and was again presented, with some minor alterations, and with a supplementary report containing specifications for untreated ties. The discussion occupied the greater part of the morning session and about half of the afternoon session, but unfortunately most of the discussion related to the proper wording of definitions of various kinds of ties. While this is of importance, the report contained matter of much greater importance which might have been discussed with advantage. An abstract of the report has already been given in our issue of March 17, and we quote below the specifications for ties, as amended, these having been omitted from the abstract. It was decided to instruct the committee to collect information as to the mileage of track laid with ties of different sizes.

Specifications for Ties.

The following woods may be used for tie timber without any preservative treatment: White oak family, cypress, redwood, white cedar, chestnut, catalpa, locust, walnut, long-leaf strict heart yellow pine.

The following woods shall not be used for tie timber without a preservative treatment approved by the purchaser: Red oak family, beech, elm, maple, gum, loblolly (short leaf, lodgepole, Western yellow pine, Norway, North Carolina pine and other sap pines), red fir, spruce, hemlock, tamarack.

All ties must be well and smoothly hewed or sawed out of sound straight-growing timber, sawed ends, and must be of specified dimensions, out of wind, with straight and parallel faces, the minimum width of either face to be not less than that given in the table of dimensions. All ties must have bark entirely removed before the ties are delivered on the railway company's grounds. Ties shall be free from splits, shakes, loose or decayed knots, or any other imperfections which may impair their strength or durability.

Except in pole ties with rounded sides, none shall be less than 8 ins. face, and in no tie shall the thickness be less than 6 ins. A variation in size will be permitted of ½-in. over in thickness, 2 ins. over in width and 1 in. over in length. In pole ties with rounded sides, the face may be less than that given in the table of dimensions below, but the least area of cross-section shall be not less than the area corresponding to the tabular dimensions, and in no case shall the face be less than 6 ins.

Class.	Thickness and face.	Class.	Thickness and face.
A	7 × 10 ins.	E	6 × 8 ins.
B	7 × 9 "	F	6 × 7 "
C	7 × 8 "	G	6 × 6 "
D	6 × 9 "		

Length in each class: 8, 8½ or 9 ft., as preferred.

Ties to be delivered along the right of way of the railway must be piled at station yards or at points between stations designated in the contract, not less than 10 ft. from the nearest rail; each pile to be of either 25 or 50 ties, built with two ties on the ground and above in alternate courses of 7 and 2, except the tops, which shall be placed to form a water shed, as shown in cut. Each pile must be plainly marked with the owner's name. A space

3 ft. wide must be left between piles to allow of easy inspection. Sawed ties must be piled separately from hewed ties.

Ties shall be cut, as far as possible, in the winter period; that is, from October to March.

YARDS AND TERMINALS.

This committee presented a lengthy report, dealing with the design and operation of coal, ore and freight piers, including coal piers with various types of coal-car dumping machines and freight piers at deep-water terminals. A typical icing station, for supplying ice to refrigerator cars, was also described. This report was distributed in a bulletin some months ago, and some written discussions printed in a later bulletin, but there was no oral discussion of the report. That portion of the report dealing with coal piers was published in our issue of March 17, and the committee's general conclusions, as adopted, were as follows:

(1) PIERS.—At rail and water terminals, the piers should be designed with a view to the most efficient, rapid and economical handling of the business, and with a view also to the future development of this business. Care must be taken to give due weight to the special conditions and features of location, traffic, etc., which exist in every case, and which render it impossible to lay down any but the most general rules for such piers. In every individual case, the length, width, number of tracks, width of platforms, details of construction and width of waterway between adjacent piers must be adjusted to best meet conditions as to shape and area of site, as well as its relation to its approaches from both land and water, the character and volume of the business and manner in which it is to be handled.

(2) COVERED LIGHTERAGE PIER.—When conditions will permit, present practice will generally suggest a length of approximately 600 ft., with two depressed tracks. If the business to be handled over the pier is expected to move quickly the width should be no greater than is necessary to provide temporary storage and shelter for the goods during ordinary detentions while waiting for cars or lighters, preferably about 100 ft. If the movement is expected to be slow and it is necessary to provide storage while waiting for cars or vessels, or for assorting, classifying, inspecting or sale of goods, the width should be increased, but generally not beyond a width of 125 to 160 ft. If the movement is not expected to have a special character, or a mixed business is to be provided for, a compromise width of 125 ft. is suggested. The space between the shed and the outer edge of the pier should be not less than 2 ft., and the clear width of waterway between piers should be, if possible, not less than four times the width of the largest vessels to be handled.

(3) OPEN LIGHTERAGE PIER.—This should, if possible, have a length of about 600 ft., and the width, number of tracks and the appliances for handling traffic should be adjusted to the particular use to which the pier is to be applied. On long piers crossovers may be necessary. For ordinary coarse freight in bulk, such as iron ore, stone, timber and similar products, the width should be from 50 to 80 ft., and there should be four tracks, with crossovers, to facilitate the handling of cars and avoid delay in transferring to or from vessels. If the business is light, or is principally heavy or costly products, such as cut stone, machinery, or miscellaneous freight not requiring shelter, a narrow pier of about 35 ft. in width, with two tracks only, is suggested.

(4) EXPORT AND STORAGE PIER.—This should be designed with special reference to the character of the commodities to be handled, whether quick movement is expected or the goods are to be held some time in storage for the accumulation of full cargoes, or for inspection or classification. There should be two tracks in a depressed pit on the pier level, which, on long piers, should be properly connected by crossovers at convenient intervals to facilitate the movement of cars. On very wide piers additional tracks on the pier level are desirable under certain conditions. Where the water front is limited or very valuable, and the conditions, volume and character of business warrant, pier sheds of two or more stories, with platform or barrel elevators and bag or barrel chutes, are used. Under certain conditions additional tracks in the second story may prove more advantageous than elevators. The length should be sufficient to properly accommodate either one or two vessels on each side at the same time, or approximately 600 to 1,400 ft. The width must be determined by the space available and the business to be handled. If quick moving, a width of 125 to 150 ft. is recommended. If slow moving, and large accumulations must be received and stored, the width may be extended, if space permits, to 300, or even 400 ft.; but excessive width is not recommended on account of the consequent increase in cost of handling. The space between shed and face of pier should not be less than 3 ft., or more than 6 ft., and the clear waterway between piers should be, if possible, not less than four times the width of the largest vessels to be handled.

(5) COAL PIER.—This should be an open pier, and where coal is to be delivered to vessels through pockets and chutes, in the ordinary way, the pier should be high enough to allow coal from drop-bottom cars to be loaded by gravity into vessels or barges. It should have three or more tracks, the outside tracks for loaded cars and the inside one on an incline to return the empty cars to the yard by gravity. The length depends upon the grade necessary to reach the desired elevation, the length of the vessels to be coaled and the number of cars which it is desired to unload at one time. Adjacent piers should be sufficiently distant to accommodate the class of service, which will depend on the length of the pier and the size of the water craft to be accommodated. Where coal cars are dumped by machinery which elevates and tilts the cars, a high pier is not necessary, and it may be at any convenient height.

(6) STATION PIER.—A city station pier served by car floats should be approximately 600 ft. long and 125 ft. wide, with a 35-ft. depressed driveway in the center. It should be a closed pier, with 3-ft. platform outside. Adjacent parallel piers should be, if possible, 200 ft. apart in the clear. Along the water street should be a bulkhead, approximately 50 ft. wide, with two-story building, the upper floor being for offices, fruit auction room, etc.

(7) GRAIN ELEVATORS.—These should be so located that cars can be run into them and unloaded, the tracks being so located that cars will feed to and from the proper part of the cluster or general yard without interference with other movements. Where possible, the tracks should be arranged to feed cars in at one end and out at the other.

RECORDS, REPORTS AND ACCOUNTS.

This committee presented a long and detailed report (printed and distributed last November), dealing particularly with the bridge department. It was practically the same report as prepared for the convention last year, but not considered owing to lack of time. The committee submitted, as information, a large number of blanks used on different railways for the compilation of information for record purposes, relating to physical characteristics of the road, bridge records, bridge inspections, etc., and also recommended a set of eight blank forms for bridge reports and records. These were criticised to some extent, but there was no general discussion on the subject.

On March 16, the morning session was called to order about 9.30; there was a recess from 12.45 to 2.30, and the afternoon session continued until 5.30 p. m.

SIGNS AND CATTLEGUARDS.

A statement made in this report called attention to the fact that there is a general and apparently well-founded complaint in regard to the rapid deterioration of the so-called galvanized wire, and the committee stated that some inquiry had been made as to the tinning of wire. It was found, however, that spelter for galvanizing costs 4½ cts. per lb., while tin costs 29 cts. per lb., so that there would necessarily be an increase in the cost of fence. The failure of the galvanizing appears to be due to the smoke and gases from the locomotives. The report included what were termed specifications for fences and catleguards, but these contained so much general information and so many particular recommendations, that they could not be regarded as specifications. Some attempt was made to simplify them, but this produced such a tangle that the report was accepted as a report of progress and referred back to the committee. The following recommendations of the committee, were, however, adopted:

1. The use of woven wire in preference to barbed wire for railway fences.
2. The use of a heavier pattern of woven wire than has generally been adopted.
3. The use of a heavy smooth wire, or a plank at top of barbed wire fence.
4. The use of the surface cattleguard in preference to the pit cattleguard.

RAILS.

This report presented specifications for rails which contained some alternative clauses representing the opposite views of the engineers and the manufacturers. The principal of these was in relation to drop tests, the engineers' clause providing for a drop test for every blow of steel, and the manufacturers' clause providing for this test for every fifth blow only. The former was adopted, and there was a rather sharp interchange of opinions between engineers and mill men, both in the committee and on the floor. For the manufacturers it was claimed that such a number of tests would decrease the output of the mill, as proved by experience. Mr. W. R. Webster, chairman of the committee, stated that the Illinois Steel Co. had followed this practice for years, and he never heard that it decreased the output; it was simply a matter of having inspectors on hand at the proper time. Mr. Abbott, of the Illinois Steel Co. (and a number of the committee), objected that the more frequent tests were unnecessary and would produce no good results. This brought out a little "experience" talk which indicated that there is growing dissatisfaction with the quality of rails delivered to the railways. Mr. Wilson (C. H. & D. R. Ry.), said that the very object of these specifications was to get better rails. Mr. Cushing (Pennsylvania Lines) said that the discussion on the part of the manufacturers assume that the railways were getting good rails, whereas the contrary is the fact. For four or five years he has been getting very poor rails, and it is desired now to obtain specifications that will result in some improvement. The rails are piped, and have split and washed heads, quite distinct from the breakages, of good rails. He remarked further that it has been claimed that the Am. Soc. C. E. type of rail section is to blame for this, and the idea has been encouraged by the mill men, but no facts have been adduced to prove it and he considered the idea quite untenable. Mr. Churchill (N. & W. Ry.), and Mr. Montfort (L. & N. Ry.) also spoke as to the unsatisfactory character of the modern steel rail, and the necessity of taking some steps to effect an improvement. When the matter came to a vote the engineers' clauses were accepted. We print the specifications, as finally accepted, in another column.

BALLASTING.

In considering this report, such diversity of view became evident over the specifications for stone ballast that it was voted to refer the matter back to the committee with instructions to confer with the committee on Track. In regard to size of stone, it was voted that this should be from 1 in. minimum to 2 ins. maximum; and as to depth of ballast, some members thought that there should be at least 12 ins. of stone. Mr. McGuigan (Grand Trunk Ry.), remarked that with only 6 ins. gravel is better than stone, as the latter has larger voids, allowing the mud to be pumped through it under the action of trains.

TRACK.

Again the meeting tackled a list of definitions, but struck a hard knot when it came to the definition of gage of track, the difficulty being as to where and how to measure the gage with rails (new or worn) which have sloping sides to the heads. The meeting adjourned at 5.30 without reaching any decision.

On March 17, this matter came up again, and was finally referred back to the committee. The consideration of definitions continued for over an hour, and was followed by a rather confused consideration of the recommendations made by the committee last year, but not then discussed. Eventually they were adopted without technical discussion. The really important subject matter then came up for discussion; namely, the spacing of bolts at joints, but everybody was then so tired of the whole matter that the recommendations were adopted almost without discussion. They were as follows:

Standard drilling for rails: End of rail to center of first hole, 2 13-32 ins.; first and second holes, 5 ins. c. to c.; second and third holes, 5 ins. c. to c. (This leaves members free to use four-bolt or six-bolt splices, as preferred.)

Diameter of hole in rail to be 3-16-in. larger than diameter of bolt used.

The punching in splices to be alternately oblong and round, to permit staggering bolts in rails high enough to allow it without flange interference. The diameter of the round hole to be 1-16-in. larger than the diameter of bolts over thread.

The heel of all frogs to be made with a steel filler block, to fit the section of rail securely bolted in, with the outer end of filler planed off ⅝-in. below top of rail, to act as a riser for the outer edge of worn treads.

The wings and throat of all frogs be blocked with a metal or wood blocking, shaped to fit rail-section; give 1½-in. flange clearance, and securely bolted to frog.

IRON AND STEEL STRUCTURES.

This committee made no report, but presented a table of upsets for the screw ends of round and square bars. A footnote to the table specified the

minimum excess at root of thread over body of bar to be 12.4%. On motion of Mr. Walter Berg (L. V. Ry.)' this was changed to 15% and the table accepted with the proviso that it be changed to correspond to the new percentage. . Some changes in the specifications for iron and steel were submitted by Mr. Schneider (American Bridge Co.) and adopted without discussion.

WATER SERVICE.

This committee's report comprised the report of 1903 (which was not considered for lack of time), and a supplementary report on water softening plants. It was accepted as a progress report.

MASONRY.

This report comprised a brief but valuable statement on the theory and design of reinforced concrete, with plans for reinforced concrete girder construction for bridges and culverts, and recommended theu se of the graphical diagrams for computation, as given in Engineering News, April 30, 1903. Last year the Association adopted the committee's specifications for Portland and natural cements, and at the present meeting it took up the committee's specifications for Portland cement concrete, and (after some minor changes) adopted them. The committee also desires to effect the uniform use of the term "reinforced concrete" instead of "concrete steel" or "steel concrete," to denote concrete which is reinforced by steel members embedded in it. The part of the report dealing with reinforced concrete bridge work was given in our issue of March 17, and in a later issue we shall give the revised specifications for concrete.

Owing to lack of time, the remaining two reports were read by title, and will be published in the proceedings. These were the reports of the Committee on Wooden Bridges and Trestles, and the Committee on Roadway. The former included specifications for trestles, piles, and bridge timbers the latter was largely historical, and presented also the general specifications for roadway construction, as amended at the meeting of 1903.

The President announced that the Board of Direction had appointed Mr. H. G. Kelley, Mr. C. W. Boynton and Prof. G. F. Swain (the two latter being members of the Committee on Masonry) to represent the Association in conference with members of the American Society of Civil Engineers, the American Society for Testing Materials, and the American Cement Manufacturers Association, to discuss the subject of tests and specifications of cement. On motion of Mr. W. M. Camp a resolution was adopted expressing the appreciation of the Association of the work undertaken by the Department of Agriculture and its Forestry Bureau in investigating the qualities of timber and methods of timber preservation.

OFFICERS.

The officers for the ensuing year are as follows: President, Hunter McDonald; Vice-Presidents, H. G. Kelley and James Dun; Treasurer, W. S. Dawley; Secretary, L. C. Fritch.

REPORT ON PROPOSED HIGH PRESSURE FIRE SERVICE FOR BOROUGH OF MANHATTAN, NEW YORK CITY.*

By Nicholas Hill, M. Am. Soc. M. E.†

Pursuant to request I submit a preliminary report on the proposed High Pressure Fire Service. The data and plans presented are tentative. The location of mains and power stations are subject to change. The estimates may be somewhat modified when time is afforded for more careful consideration. The drawings and maps presented are diagramatic and intended to illustrate on broad lines a method of introducing an auxiliary fire service. The following conclusions may, however, be safely drawn:

(1) It is possible to construct such a system on the general lines herein presented, subject to such modifications as a thorough study may suggest.

(2) A high pressure fire service may be installed with an expenditure not exceeding the limits of the estimates furnished.

AREA PROTECTED.—I have been somewhat guided by Fire Chief Croker's views in selecting the district in which to install the first section of the proposed service. A large number of factories, wholesale establishments of various kinds, and buildings not fireproof in construction are located within the confines of this area. I understand the losses from fire in this section are heavier than in any other district of equal area in the Borough of Manhattan. It is a district containing many buildings similar in character and construction to those situated in the locality where the Baltimore fire originated. The area outlined is bounded generally by 23d St. on the north; Broadway to 14th St. to Fourth Ave. and the Bowery, on the east; Chambers St. on the south and the North River on the west. A map (Fig. 1) is appended showing the boundaries of this district and provisional locations for the pumping stations.

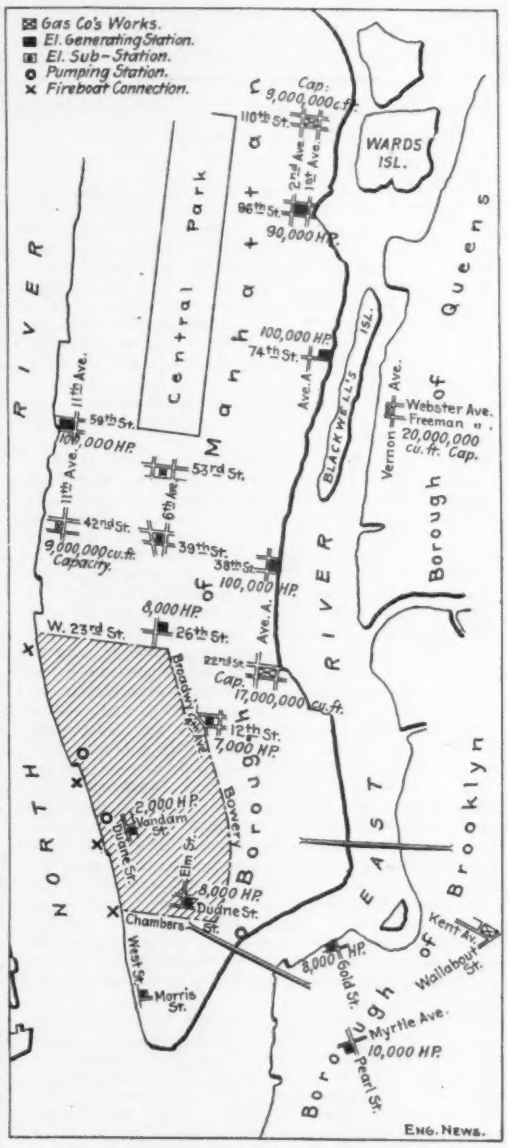


Fig. 1. Outline Map of Manhattan Borough Showing District Included in Proposed High Pressure Fire Service System, Pumping and Power Stations, etc.

(Shaded area indicates territory covered by high-pressure piping.)

NUMBER OF PUMPING STATIONS.—It is proposed to erect three pumping stations, definite locations for which cannot be fixed until the relative cost of land and other questions have been considered. Each station will be capable of pumping to any part of the distributing system. The subdivision of the pumping plant was deemed advisable on the ground that should any one station be disabled or rendered ineffective during the course of a conflagration, two-thirds of the output of the plant, or double the present capacity of the fire department would be available.

FIRE BOAT CONNECTIONS.—Provision has been made for direct connections to the high service mains at various points on the water front so that in the event of the total disability of the pumping plant the fire boats may be used to pump into the proposed system. These boats, five in number, have a combined capacity of about 2,400,000 gallons per hour, or 40,000 gallons per minute against a pressure of 150 lbs.

CAPACITY OF PRESENT FIRE ENGINES.—About 25 engines respond to a fourth alarm of fire in the district mentioned. Their combined capacity equals about 900,000 gallons per hour against a pressure of 125 lbs. The fire boats directly connected to the high service mains would more than double the output of the engines.

CAPACITY OF PUMPING PLANTS.—The present plans contemplate a capacity of 1,000,000 gallons per hour at each of the three stations, or a combined capacity of 3,000,000 gallons per hour. The pressure at the station will be 300 lbs. The minimum pressure at the hydrant is estimated at 200 lbs. The following facts are interesting: The new service will furnish more than three times the water now supplied at one fire by the present fire equipment. The pressure will be more than double that now maintained. Each station will furnish 32 streams through 3-in. hose with 1¼-in. nozzles. Each hydrant will deliver approximately 2,600 gallons per minute, or five such streams. Two hydrants are proposed for each street intersection giving ten such streams. From the four corners of a block 40 such streams may be played on a fire within the block. Forty streams are equivalent to about 20,000 gallons per minute, or 1,200,000 gallons per hour. About 33⅓% more water can be delivered on a fire from the four corners of a block than is now furnished at a fourth alarm fire with the engines widely scattered. Concentration of the fire-fighting force saves time and frictional losses in hose, and facilitates the operations of the officers and men. Ninety-six lines of 3-in. hose, not exceeding 350 ft. in length, may be concentrated on a single fire when the three stations are operating simultaneously.

COMBINED USE FOR STREET CLEANING AND FIRE PROTECTION.—It has been proposed to put in a system for the combined purposes of fire protection and street cleaning. I consider this ill-advised and impractical. The nominal pressure on the system is 300 lbs. The actual pressure may reach 600 lbs, due to water hammer and the presence of air in the mains. No hydrant can be built to withstand such conditions and undergo rough usage at the hands of ignorant workmen. The system might fail at a critical moment if used for other than fire purposes. Our experience with the hydrants on the low pressure service of the Croton amply justifies the above statement.

The pressures which will be carried on the fire service are too great for street cleaning. The city should provide proper stand-pipes at street intersections, connected with the croton system for the specific uses of the Street Cleaning Department.

SOURCE OF ENERGY.—Three sources of energy may be used—steam, gas and electricity. Steam need not be considered, unless absolutely necessary, on account of the high first cost of the plant and the expense of operation. The three stations will probably not be operated more than 240 hours per year. The plants, to be effective, must start instantly upon the stroke of a gong. Steam pressure must be maintained for every minute in the year to accomplish this in a steam plant. Fuel will have to be fed continually, therefore, to maintain stations operating ten days per year. This is not the case with gas or electricity if the energy is procured outside. A gas engine may be started in a few seconds and when closed down is using no fuel. An electric motor may be started by throwing a switch and the current shut off with equal facility. No final arrangements can be made for the supply of current or gas until the project takes more definite form.

ELECTRIC POWER AVAILABLE.—A careful investigation leads me to believe the electric companies in Manhattan are amply equipped, so far as power is concerned, to give us the maximum amount of current needed at any time if properly constructed cables in duplicate are laid and interconnected to prevent a possible interruption in the supply of electricity. The three plants will require about 15,000 HP. when working at their full capacity. The accompanying map (Fig. 1) shows the location of the several electric power stations

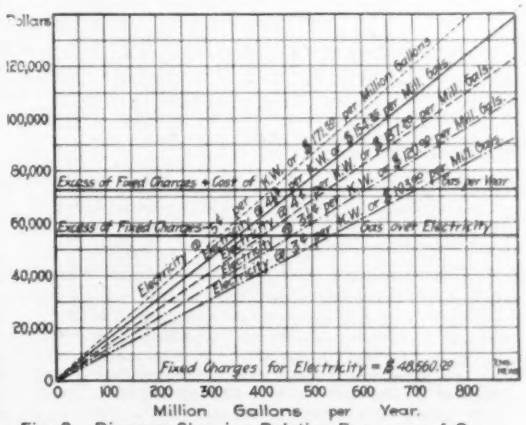


Fig. 2. Diagram Showing Relative Economy of Operation in Gas Engine and Electrically Driven Pumping Plants.

(Capacity 1,000,000 gallons per hour against a pressure of 300 lbs. per sq. in.)

*Report submitted to John T. Oakley, Commissioner of Water Supply, Gas and Electricity, New York City.

†Chief Engineer, Water Department, Park Row Building, New York City.

and the horse-power in each. The proposition from the gas company's standpoint is rather more difficult. To furnish the necessary gas involves long lines of mains not less than 30 ins. in diameter. This entails heavy expense and special generators to insure the requisite amount of energy at any moment. The additional plant would create an annual expenditure of about $50,000 per year for maintenance and repairs. This may be reduced on further investigation, but I have not considered it safe to figure on less than this amount in the estimate of the cost of operating a gas plant.

COST OF POWER.—The cost of the electric current cannot be definitely ascertained until the conditions of operation and the locations of the pumping stations are determined. I have assumed a rate in the following estimates which I feel assured can be obtained. The load factor on the pumping station is small as the stations are operated approximately ten days per year, so if electricity is paid for, only when used, the question of cost is not great in comparison with other expenses of operation and maintenance. The total cost, therefore, will not be materially affected by any reasonable change from the rates assumed. Allowance has been made for laying the necessary electric cables to connect the pumping stations. If gas is used the company will provide the pipes and plant.

PLAN OF STATIONS.—The mechanical efficiency of the gas and electric plants is approximately the same. In comparing the use of gas and electricity as the probable source of energy it may be well to present the following points in favor of electricity:

(1) Economy in first cost of machinery and buildings.
(2) Economy in space necessary for installation, thereby reducing cost of land required.
(3) Economy in cost of wages, maintenance, repairs and renewals.
(4) Simplicity.

The relative cost of power cannot be stated with accuracy until the price for which gas can be had is determined. Following is a statement of the comparative cost of one pumping station operated either by gas or electricity, an estimate of the probable operating expenses and fixed charges per annum, a similar summary for the three stations and an estimate of the total cost of high pressure fire service complete. (See Fig. 2.)

Cost of One Pumping Station.

	Electric.	Gas.
Number of units in station	4	6
Capacity in million gallons per hour	1	1
Estimated number of hours plant will be in operation per year	80	80
Cost of motors and turbines including piping, foundations, switchboard and wiring and cables	$255,000	
Cost of gas engines and pumps, including piping, foundations and auxiliaries complete		$448,000
Cost of bldgs., foundations and land	90,000	270,000
Total cost	$345,000	$718,000
Cost of wages per annum	$7,650	$18,150
Cost of gas per year		17,000
Cost of electricity per year at 4½ cts. per KW. hour	13,200	
Cost of oil, waste and supplies per yr	300	300
Cost of repairs per year	2,400	3,600
Total cost of operation	$23,550	$39,050
Interest and depreciation	26,710	55,000
Refunding sinking fund	11,500	27,000
Total cost per annum	$61,760	$121,050

Cost of Three Pumping Stations.

	Electricity.	Gas.
Cost of three stations (7) × 3	$1,035,000	$2,154,000
Operating expenses and fixed charges per annum for three stations (15) × 3	185,280	363,150

Summary of Total Cost.

Pumping stations	$1,035,000	$2,154,000
Mains for distribution system complete with gate valves and hydrants	2,107,000	2,107,000
Telephone system	150,000	150,000
Total cost	$3,292,000	$4,411,000
Add 10% contingencies	329,200	441,000
Add 10% superintendence	329,200	441,100
Total	$3,950,400	$5,293,200

USE OF FRESH WATER.—Careful attention has been given to the use of salt water in connection with its deliterious effect upon the contents of buildings. Salt water is more injurious to the hydrants, gate valves, pumps and distributing system than is fresh water. If salt water is used the depreciation on the plant will be increased. The plans submitted provide for both fresh and salt water connections at the pumping stations. The fresh water is drawn from the Croton system. This system is capable of supplying any or all the stations. In the event, however, of any shortage of supply of fresh water the salt water may be immediately used without interference with the operation of the plant.

In making the above modification I wish to emphasize that the original salt water system is not assailed or detracted from. The use of fresh water, with salt water available when needed, as suggested, removes one of the chief objections offered to the proposed service and adds thereby to the feasability of the proposition.

In conclusion I would respectfully suggest that there are several other methods by which additional fire protection may be obtained, some of which may be more economical. Time has not permitted a study of these methods. I was asked to report on the above system and I have confined myself to this work. I would strongly recommend, however, that should appropriation be made to increase the efficiency of the fire service, the parties in whose hands the erection of the work is placed be allowed full opportunity to study other systems and be requested to make a subsequent report on the same before the city finally commits itself to any one method

REPORT ON PROPOSED HIGH PRESSURE FIRE SERVICE FOR BOROUGH OF BROOKLYN, NEW YORK CITY.*

By I. M. de Varona, M. Am. Soc. C. E.†

The high pressure high service should be limited, aside from special cases, to the commercially congested districts, where, in view of the large interests involved, it is of paramount importance speedily to bring a fire under control so as to prevent its spread, and where, consequently, the high pressure fire system provides a margin of safety of much greater value than the expense involved. In this borough the districts in which the high pressure fire service can be advantageously installed are those shown in the accompanying maps (Figs. 1 and 2). They are as follows:

(1) Coney Island district, area about 147 acres.

(2) Dry goods and high office building district, area about 375 acres.

(3) Lower water front district, area about 845 acres.

(4) The section along the water front in the eastern district, extending approximately from Division Ave. to North 14th St., and from the river front to somewhat beyond the line of Berry St., for which it may hereafter be advisable to make provision, area about 300 acres.

CONEY ISLAND DISTRICT.—Special conditions, widely differing from those in any other district within the borough, exist here. The main buildings are valuable frame structures of moderate height, covering the ocean front for a distance of approximately 3,000 ft., and in case of fire it must be checked almost immediately in order to prevent a genral conflagration, consequently the fire risk is great, as well as the difficulty of obtaining insurance. Furthermore, there are only two fire engines and one truck on the island and within a period of 40 minutes after the fire alarm no more than six engines could be brought into service. The installation of a high pressure fire service here would, therefore, prove particularly advantageous, affording an instantaneous supply when needed and this at a reduced expense, since the plant is to be operated by the regular employees of the sewage station, thus reducing the cost for salaries and maintenance, while the cost of installation of separate fire stations will also be saved. The pressure provided under this plant would be from 135 to 140 lbs. at the hydrants, which would be more than ample for all fire purposes, in view of the small height of the buildings in that section.

DRY GOODS AND HIGH OFFICE BUILDING DISTRICT.—This district extends from Ft. Green Pl. on the east to the river front on the west, and from Orange and Tillary Sts. on the north to Dean St. and Atlantic Ave. on the south. The main features of the proposed plan for this district are shown by Fig. 1. There will be two 20-in. mains with 16-in. extensions and 12-in. and 8-in. laterals.

LOWER RIVER FRONT DISTRICT.—The boundaries of this district are shown by Fig. 1. It extends from the Erie Basin to the Navy Yard, with the exception of the portion included in the dry goods and high office building district, and is bounded in the southerly portion by Richards, Wolcott, Dwight, and Columbia Sts., Hamilton Ave., Hicks St., Rapelyea St., Henry St., Harrison St., Clinton St. and Atlantic Ave. In the northerly section it is bounded by Tillary St., Navy St., East River and Doughty St., Hicks, Orange and Washington Sts. The area of the northerly section is about 345 acres, and that of the southerly section about 500 acres, making, as previously stated a total area of about 845 acres. The general plan for this district is shown by Fig. 1.

If a sufficient appropriation could be obtained, it might be advantageous to provide the water front, extending from Division Ave. to North 14th St., and from the river to somewhat beyond Berry St. with a high pressure fire system, but under present conditions it has not seemed necessary to further discuss this plan here. Should it be desired to extend the service to this district, the plan for the same can be readily prepared.

WATER REQUIRED FOR FIRE PURPOSES.—The total quantity of water used for fire purposes is relatively too insignificant to deserve consideration, being, in fact, so small as to fall well within the margin of error under any system of measurement adopted to determine the daily consumption. The figures are, in Brooklyn, 27,000,000 gallons in 1901 and 25,000,000 gallons in 1902, and in the combined Boroughs of Manhattan and the Bronx less than 40,000,000 gallons per year for several years, and probably less than 50,000,000 gallons per year, on an average, for the last ten years, which represents about 1-20 of 1% of the consumption both for Brooklyn and for Manhattan and the Bronx. The contributing reservoirs, even under extreme conditions always hold several times the total amount of water used for fire purposes in this borough in a whole year on the basis of the figures reported for 1901 and 1902 given above. The main trouble has been due to the lack of sufficient distribution pipes and mains, hydrants, etc., to adequately deliver the water where needed in case of fire.

RELATIVE ADVANTAGES OF FRESH AND SALT WATER.—Popularly, a "salt water system" is always considered as characteristically a high pressure system, under which fire engines would not be used, and a "fresh water system" as the type of a system under which fire engines are required, and, for expedition and brevity, these popular terms have been so used, although it is needless to say that if the water is available there is no difficulty in installing a fresh water high pressure system. It has already been shown, in comparing the advantages of the use of salt and fresh water that the saving in water is too trifling to deserve consideration. The main points to determine the relative advantages of the use of fresh and salt water are as follows:

In favor of fresh water: (1) The decreased damage from water in moderate fires, where the merchandise is not entirely destroyed. (2) The longer life of the pumps, mains, hydrants and other fixtures, and decreased effects of galvanic action where iron is used in combination with other metals. (3) Possible economy in the location in this borough of a reserve station.

The disadvantages attending the use of fresh water would be, on the other hand: (1) The probable suppression of the proposed sprinkling and washing of streets by using water from the high pressure system. (2) The waste of fresh water from leakage or seepage from the mains while not under service.

After a full consideration of this question, I have decided to recommend a high pressure system normally supplied with fresh water, but so designed that river water, and at Coney Island sea water, can also be used in cases of emergency.

AVAILABLE WATER SUPPLY.—As the primary requisite under this plan is an adequate amount of fresh water, careful computations have been made to determine the quantity which could be drawn from our trunk distribution mains without seriously affecting the pressure in the city, assuming that all the trunk mains now under contract were laid, and the results show that under these conditions, even assuming that the fire took place during the morning period of maximum daily consumption, water could be drawn, during that period, at the rate of 20,000,000 gallons per day at either station in the river front and dry goods and high office building districts, without reducing the pressure in the trunk mains below the existing pressure, and leaving an available pressure higher than the present one throughout the general distribution system, owing to the more adequate size of the lateral mains provided. As the consumption decreased throughout the day, the available draft for fire purposes, would, of course, correspondingly increase. In other words, the mains would readily furnish in 24 hours an amount of fresh water practically equal to that consumed for fire purposes in Brooklyn in a whole year in 1901 and 1902. The improbability of ouf being compelled to use river water is thus apparent. In fact, the necessity for its use would only arise in case of a conflagration which would tax the capacity of the high pressure plant, in which case a point might be reached at which it would be advisable to cut off the fresh water supply from the high service station and to draw from the river.

In the Coney Island district, with the proposed new mains, the present water supply would be sufficient for ordinary fire purposes; but in case of an extensive conflagration it might prove inadequate and salt water would then have to be used. The pumps and fixtures for this system have, therefore, been specially adapted for service in such a contingency. On the completion of proposed connections with the Ridgewood system the fresh water supply at Coney Island will be ample for all probable fire service requirements and there will be then few probabilities of our having to pump salt water under any circumstances.

ANALYSIS OF RIVER WATER AND SALT WATER.—A thorough examination of the river front to find the sewer outlets, and numerous analyses of the river water and the water at Coney Island have been made to determine their condition at various depths, distances from the shore and stage of the tide, to enable us to locate the intakes for the pumping stations and fire-boat connections, so as to guard, as far as possible, against contamination in the water that may have to be pumped from the river or at Coney Island. The results of these analyses have been tabulated, but, in spite of their interest and value, are here omitted for the sake of brevity.

FIRE STREAMS PROVIDED, PRESSURE.—At the Coney Island district provision has been made to supply

*Abstract of Report made to Thomas F. Byrnes, Deputy Commissioner, Water Supply, Gas and Electricity, New York City.

†Chief Engineer, Water Department, Borough of Brooklyn, Municipal Building, Brooklyn, N. Y.

11 streams discharging 250 gallons per minute each under a pressure at the engine of 150 lbs. and at the hydrants of from 135 lbs. to 140 lbs. apiece. This pressure will be sufficient to throw, with a 2½-in. hose and 1¼-in. ring nozzle, a stream of about 380 gallons per minute to an effective vertical height of about 90 ft., under 200 ft. of ordinary hose, the pressure at the nozzle being about 50 lbs. Sufficient fire protection would thus be secured in this district, especially taking into consideration the character of the buildings existing therein.

For the river front and dry goods and high office building districts, provision has been made to supply water for from 25 to 30 streams discharging 500 gallons per minute each, which would be at the rate of from 18,000,000 to 22,000,000 gallons in 24 hours. The pressure at the engines should be about 300 lbs., which would correspond to about 225 lbs. at the most distant hydrant in the system. In Philadelphia, with only 230 lbs. pressure at the pumps, a single 2-in. stream was thrown 315 ft. horizontally and 230 ft. vertically, which would be considerably above the highest building in the Borough of Brooklyn.

In Philadelphia permits have been refused for automatic sprinklers and special fire protection to be permanently connected with the high pressure service, provision being simply made for risers, to which, in case of fire, the hose can be attached. It seems needless to discuss here this question, as it will be settled by the fire department, who, under the proposed plan, will take charge of and operate the high pressure system (with the exception of the Coney Island district), this department attending simply to the maintenance and repair of the mains.

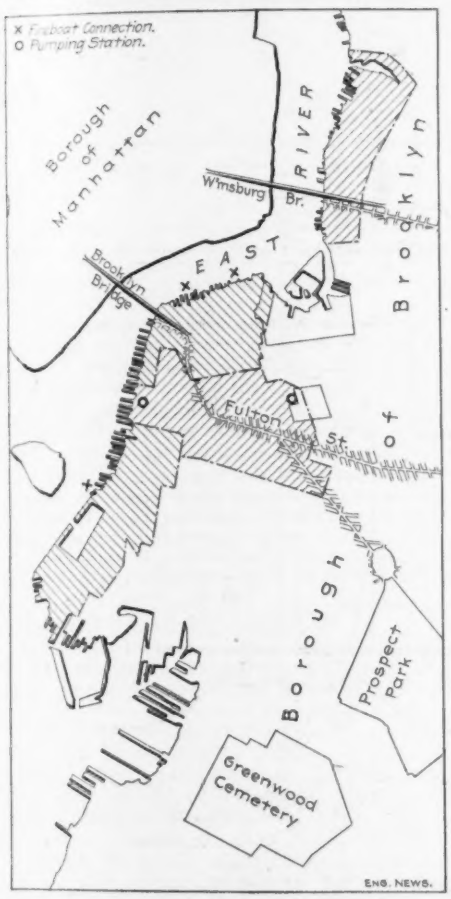


Fig. 1. Outline Map Showing Proposed Dry Goods, Office Building and River Front High Pressure Fire Service Districts, Borough of Brooklyn.

PUMPING STATIONS, NUMBER AND LOCATION.—For the Coney Island district, the location of the pumping station adjoining the sewage plant has such obvious advantages under the contemplated plan of operation that it has not been deemed necessary to discuss any other site. It will be free from danger of interruption of the supply due to conflagration in the surrounding area.

In determining the most favorable location and number of stations required for the river front and dry goods and high office building districts, we had to consider the available water supply, location of sources of power to be used, freedom from interruption of service by possible conflagration, length of mains required to reach the district to be protected, and value of the lands and buildings to be acquired. After a full consideration of these details, and also of the difficulties attending the use of gas engines, to which reference will be made hereafter, it was considered advisable to establish two stations, i. e.:

The main station at the foot of Joralemon St., as shown in Fig. 1 and a reserve station, with two-thirds the capacity of the main station, at the corner of Willoughby and St. Edwards Sts., also shown in Fig. 1.

The station at the corner of Furman and Joralemon Sts. is not very favorably located to obtain either gas or electric power; but, on the other hand, it is centrally situated in regard to the system of which it forms a part, the supply of fresh or salt water can be readily and cheaply secured, the character of the surrounding buildings diminishes the probability of a conflagration which would cripple the station, and the buildings and lands to be acquired can probably be purchased at a comparatively small cost.

The reserve station adjoins on the north the fire department repair buildings; on the east it fronts on Ft. Greene Park; to the south it fronts on Willoughby St., with Raymond St. jail on the other side of the street; and to the west it adjoins a substantial brick factory. This location was deemed desirable on account of its particular freedom from risk from any large conflagration and the facilities to supply therefrom the river front and dry goods and high office building districts.

With two stations thus located there should be little danger of interruption of the high pressure fire service from any cause.

POWER AND ENGINES.—Steam being obviously unavailable, the choice of the power to be used lies between gas and electricity, and much consideration has been given to their relative advantages. If the first cost and expense of maintenance and operation of the electric and gas plants were nearly alike, and the freedom from possible interruption of the service were also on a par, common prudence would dictate the equipment of the station with both electric and gas engines, thus minimizing the chances of a total crippling of the service and I would have been glad to find that such an arrangement was practicable without incurring unwarranted expense. But the much larger cost of the gas plant and of the mains required to furnish that power to the station have compelled me to abandon the idea of having any gas engines at the main station and to recommend that both this station and the reserve station be entirely equipped with electric plants, relying for the protection of the service from interruption on two independent sources of supply and, to a certain extent, on the provision for a reserve station in addition to the main one. I had hoped that the Brooklyn Rapid Transit might also have agreed to furnish us electrical power, but in answer to my inquiry they stated that they were unable to do so. The electric power would be furnished by the Edison Co. from the station located at the foot of Gold St., from which two independent underground feeders will carry the current to our main and reserve stations. The Gold St. station is directly connected with the station at the foot of 65th St., so that in case of a suspension of service at the Gold St. station the current would still be furnished from the station at 65th St. The location of the Gold St. power station is shown in Fig. 1, as well as that of the gas works from which gas could be furnished to our stations.

The following figures show the difference in cost between the gas and the electric plant and necessary mains and feeders for gas and electricity required to furnish power to the proposed stations:

MAIN STATION.

Gas Plant:		
Cost of engines	$126,500	
" " pumps	110,000	
" " building	100,000	
" " gas main (single main)	35,000	
Total		$371,500
To which, in case two gas mains were adopted, there should be added		25,000
Making a total of		$396,500
Electric Plant:		
Cost of motors	$60,000	
" " pumps	25,000	
" " building	75,000	
" " electric feeder and conduit (duplex)	35,000	
Making a total of		$195,000
Saving in electric plant (2 gas mains)		201,500
Saving in electric plant (1 gas main)		176,500

RESERVE STATION.

Gas Plant:		
Cost of engines	$80,500	
" " pumps	70,000	
" " building	70,000	
" " gas main (single main)	20,000	
Total		$240,500
To which, in case 2 gas mains were adopted, there should be added		15,000
Making a total of		$255,500
Electric Plant:		
Cost of motors	$36,000	
" " pumps	15,000	
" " building	60,000	
" " electric feeder and conduit (duplex)	5,000	
Making a total of		$116,000
Saving in electric plant (2 gas mains)		$139,500
Saving in electric plant (1 gas main)		124,500
The saving in both stations, therefore, assuming a single gas main and duplex electric feeders, would be		$301,000
And if two gas mains were adopted, the total saving would be		$341,000

At the Coney Island station there will be three gas engines each of 150 HP. At the main station at the foot of Joralemon St. there will be five electric motors of 750 HP. each, and at the reserve station there will be three similar motors.

It is unnecessary to take into consideration the value of the electric current or gas used, since the main station would probably not be operated on an average more than two hours per month and the reserve station might not be used more than one or two hours per year.

At the Coney Island station the gas supply is located within five blocks, while the nearest electrical power station is at the foot of 65th St., six miles distant. At present there are only overhead feeders, which, over such a length, are liable to cause interruption of the service, although the Edison Co. state that they will have underground feeders installed by the middle of May. Even under these conditions, however, owing to the small amount of power required at this station it does not seem that the difference in cost in this case would outweigh the probable greater freedom from interruption of the service, especially as this difference would be decreased by about $5,000, which is the excess of cost of the electrical conduit and feeders which would have to be laid by the electric company over the meter which the gas company would install. Even if the chances of accident to the electric feeders when placed underground be considered slight, the nearness of the gas station almost precludes the chances of such an interruption, and therefore for this district I have adopted gas engines.

PUMPS.—For the Coney Island station triplex plunger pumps will be used, as this type of pump will give practically a constant discharge and can be readily geared so as to be connected directly to the gas engine. If a turbine pump were used, it would be necessary to connect by means of belting or chain drive, and the high speed would make this form of power transmission undesirable. For the required service three pumps will be installed having a capacity of 1,200 gallons per minute each, or a total of 3,600 gallons per minute, which is equivalent to a total of about 5,200,000 gallons in 24 hours.

At the main station at the foot of Joralemon St. there will be five turbines, each having a capacity of about 2,800 gallons per minute, which would be equivalent to slightly more than 20,000,000 gallons in 24 hours. These turbines would be directly connected with and operated by electric motors, the speed of which would be the same as that of the turbines when running at their rated capacity.

At the reserve station there will be three such turbines of the same capacity and similarly connected, so that the capacity of this station will be slightly over 12,000,000 gallons in 24 hours, or somewhat less than two-thirds of that of the main station.

This combination of the electric motors and turbines is simple and comparatively inexpensive.

DISTRIBUTION.—The mains will be of cast iron, with lead joints of special design. The mains, specials and hydrants will be tested at the foundries to a pressure of about 600 lbs., and when laid they will be tested to a pressure of about 450 lbs. The hydrants will be so located in the dry goods and high office building districts that the whole number of streams, representing the full capacity of the plant (i. e., from 25 to 30 streams) can be concentrated on any block within that district. At Coney Island the hydrants will be also located so as to bring the full number of streams that can be supplied by the plant to bear on any one block within the district. In the river front and dry goods and high office building districts the mains have been so laid out that there will always be two distribution mains leading to any district and these are so cross connected that in case of a break in the main only a short section may be put out of service. For this purpose a suitable number of gates will be provided. At Coney Island, the pressure being comparatively low and the area to be protected small, it has not been deemed so important to provide more than one delivery main (16 ins. in diameter) from the station to Surf Ave. If this single main were replaced by two 12-in.

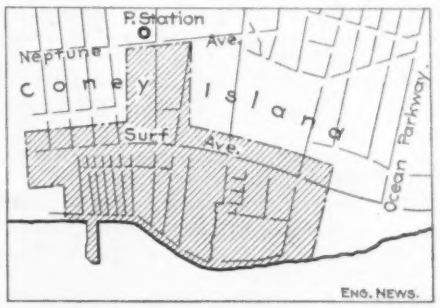


Fig. 2. Outline Map of Proposed Coney Island High Pressure Fire Service District, Borough of Brooklyn.

mains, the additional cost would be approximately $3,200.

A system of telephone boxes is recommended, communicating with the high pressure pumping stations. These telephone boxes should be so located that any fire in the protected district can be readily watched by a man stationed at one of these telephone boxes. Their definite location, however, will be determined by the fire department, who, presumably, will install and control these telephone boxes.

The following is a summary of the cost and annual charges for the three districts discussed:

District.	Cost.	Annual Charges.
Coney Island	$90,000	$3,906.40
Dry Goods and High Office Bldg.	885,000	51,818.73
River Front	500,000	19,435.00
Total	$1,475,000	$75,220.13

District.	Area, acres.	Cost per acre.	Annual charges per acre.
Coney Island	147	$612.24	$26.98
Dry Goods and High Office Building	575	1,539.13	90.12
River Front	845	391.72	23.00
Total	1,567	$941.29	$48.00

District.	Assessed valuation of improvements.*	Ratio of cost to assessed valuation.
Coney Island	$1,000,000	9%
Dry Goods and High Office Building and River Front.	61,000,000	23%

*Does not include contents of buildings.

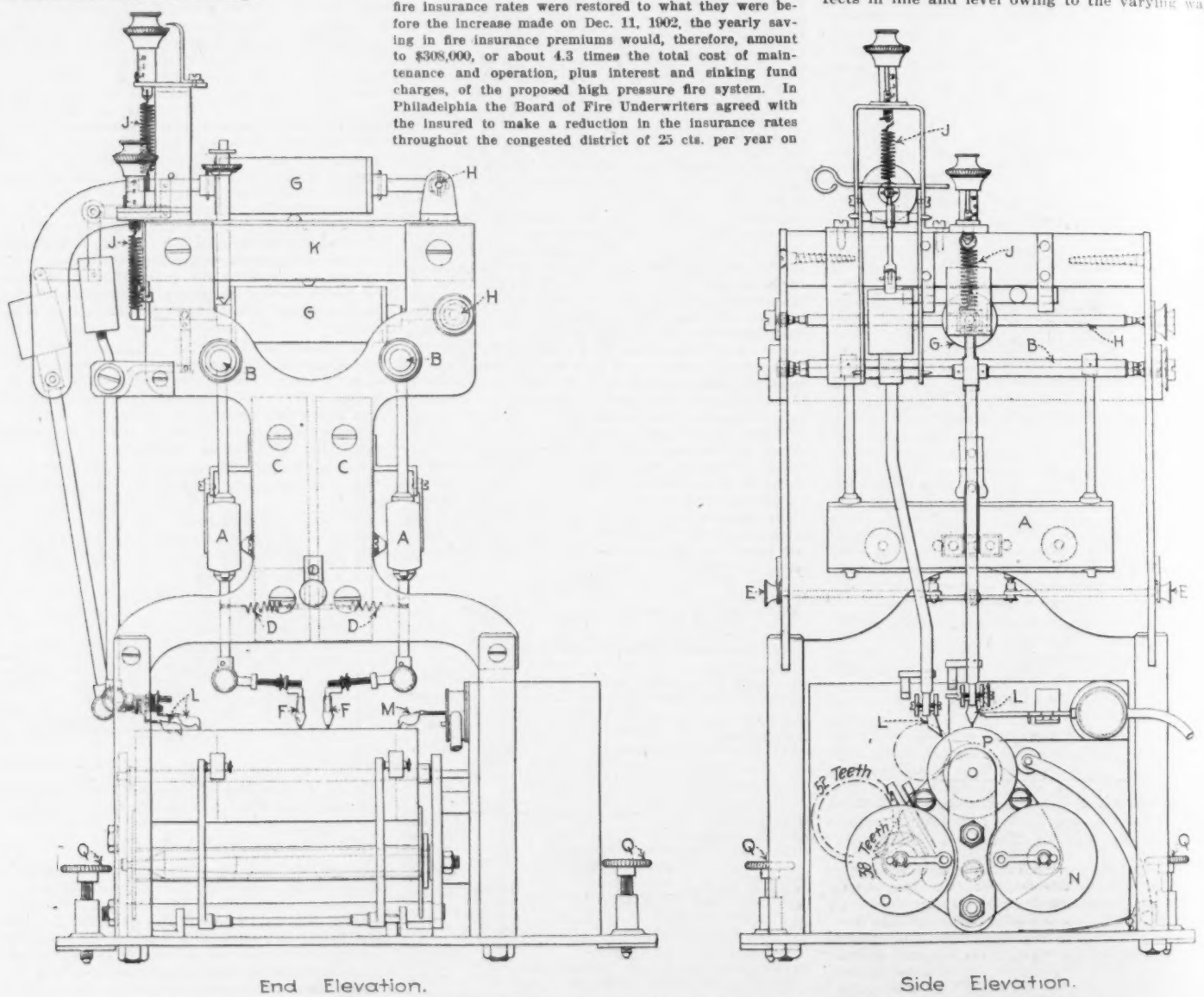


FIG. 1. RECORDING APPARATUS OF TRACK INSPECTION CAR; NORTHERN RAILWAY OF FRANCE.

FIRE LOSSES AND INSURANCE RATES.—In estimating the relative value of the high pressure fire system it will be of interest to note that the total number of fire engines at present in Greater New York (exclusive of the Borough of Richmond) is 140, distributed as follows:

Manhattan and the Bronx	77
Brooklyn	57
Queens	6
Total	140

The number of fires in the Borough of Brooklyn during the last three years averaged about 3,000 per year, and the losses by fire in Brooklyn amounted

In 1901, to	$2,932,839
And in 1902, to	2,487,580

I have been unable to obtain the tabulated figures for 1903.

According to the data kindly furnished by Mr. A. B. Roome, Manager of the Brooklyn and Long Island Department of the Continental Fire Insurance Co., and collated from the reports of the Fire Insurance Salvage Corps of Brooklyn, L. I., the total insured value for the entire year of 1903 in the districts to be protected by the high pressure fire system, exclusive of Coney Island, was approximately, $22,000,000. The average yearly rate of fire insurance for 1903 was approximately 85% for each $100 of value insured, so that the annual premium paid on the insurance in the protected district was approximately $1,870,000.

The report of the Board of Fire Underwriters announcing the change of fire insurance rates was published on Dec. 3, 1902, and on Dec. 11, 1902, the average rate of insurance in the districts to be protected was advanced on an average of about 20% above the previous rates, or say, from 71c. to 85c. per $100, so that the annual increase in premiums for 1903 amounted to $308,000.

Several statements have been made of the disposition of the underwriters to lower the insurance rates as soon as better fire protection is secured. If, on the completion of the high pressure fire system herein recommended, the fire insurance rates were restored to what they were before the increase made on Dec. 11, 1902, the yearly saving in fire insurance premiums would, therefore, amount to $308,000, or about 4.3 times the total cost of maintenance and operation, plus interest and sinking fund charges, of the proposed high pressure fire system. In Philadelphia the Board of Fire Underwriters agreed with the insured to make a reduction in the insurance rates throughout the congested district of 25 cts. per year on every $100 insured, as soon as the high pressure fire service to protect that district was in operation, the rebate to be made in the following manner:

When the pipes were laid so that the fireboats could be extended to the congested district	15 cts.
When the pumping station was complete	10 "
Total	25 "

If the reduction in insurance rates in Brooklyn were made equal to that above quoted for Philadelphia, the yearly saving in insurance throughout the districts to be protected would amount to $550,000, or about 7.7 times the total cost of maintenance and operation, plus interest and sinking fund charges, of the high pressure fire system. To this saving in fire insurance rates must be added the reduction in the aggregate fire losses, which would particularly benefit the insured, since in many cases, especially in those of manufacturing establishments and business houses the amount of insurance by no means totally covers the whole fire loss.

The plan herein recommended can be completed in about one year from the beginning of work.

TRACK INSPECTION CAR ON THE NORTHERN RAILWAY OF FRANCE.

The Northern Railway of France has for some time employed a track inspection and registering device for use especially on lines operated at high speeds, and this is described in the December number of the "Revue Generale des Chemins de Fer" by Mr. M. Rossignol, Assistant Chief Engineer. The principle employed in noting the condition of the track is that a sufficiently exact idea of its stability and regularity can be obtained from the movement of a car traveling upon it. Owing to the play between the wheel flanges and rail heads the car does not follow the track exactly, and it is influenced very unequally by defects in line and level owing to the varying way in which it strikes them. But from the law of probabilities the condition of maintenance of the track can be determined approximately by the way in which the car rides.

To render the various observations as comparable as possible, they are all made with the same car, attached at the rear of a train, but with a special baggage car interposed to diminish influences due to the train itself. This special car is coupled tightly to the train and the track in-

spection car. It would be desirable to make the observations always at the same speed, but this would involve the trouble and expense of special trains, and consequently they are made at various speeds. Under these conditions, a study of the results enables the following conclusions to be drawn:

(1) Vertical oscillations are influenced very little by the speed, owing largely to the action of the springs.

(2) Lateral shocks, on the contrary, increase very rapidly with the speed, but their relative importance at various speeds can be approximately

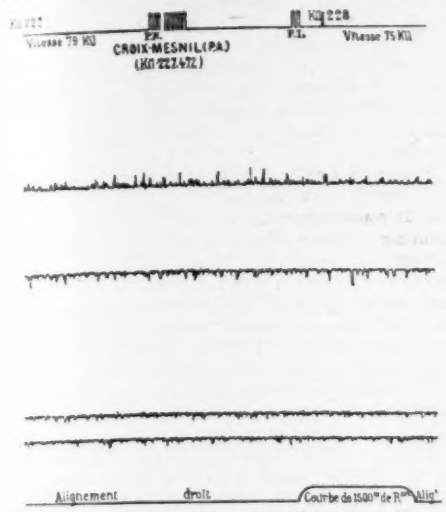


Fig. 2. Inspection Record of Well-Maintained Track.

reduced to that of a given speed by means of coefficients.

The car used for the inspection trips, and built especially for this service, is a four-wheeled car, 32 ft. long over the end sills, with a wheelbase of 18½ ft. Four long plate springs attached to the frame rest on the axle boxes. In the center is the registering apparatus, and at each end is a large open platform, protected by the roof and sides, the rear platform being separated from the recording room only by a glass partition, so as to allow of a good view from the interior in case of bad weather. At each side of the recording room is a bay window, with a seat, which arrangement facilitates the work of reading the mile or kilometer posts and noting such special points as stations, junctions, tunnels, etc.

Complete registration would include six movements: (1) Vertical movements above and below a datum line; (2) Transverse movements to right and left of the center line; and (3) Longitudinal movements before and behind a transverse datum line. The latter, however, are due rather to the tractive effort than to the condition of the track, and it is sufficient to record vertical and transverse movements.

It was considered that the simplest means of obtaining the record was to employ pendulums, as was done by Mr. Sabouret in 1890 to deduce from the movements of a locomotive when running the intensity of the forces exerted upon the track. A mass able to oscillate from its position of equilibrium shifts from this position when its support sustains a shock. It returns to position by a series of oscillations, but the initial movement is a measure of the intensity of the shock. A difficulty in registering a series of shocks at short intervals, as in this case, is to ensure that the mass returns to its normal position quickly enough to prevent the interference of successive shocks. To provide for this, it is necessary to use a stop which allows the weight to move only to one side of its normal position. It is finally necessary to so design the suspension of the weight as to prevent unimportant and rapidly deadened displacements.

Mr. Sabouret, who experimented only with lateral shocks, realized this last condition by the use of short and heavy pendulums. In the track inspection apparatus, however, for registering the same shocks, the pendulums are made a little lighter, but have their oscillation shortened by means of springs. Then by varying the stiffness of the springs, the maximum extent and duration of the oscillations can be reduced to limits appropriate to the car on which the tests are to be made. For registering the vertical shocks, the same principle is used; lead weights oscillate around horizontal axes, striking against a horizontal frame.

The various oscillations are recorded on a sheet of paper traveling at constant speed, and on which are marked (as the car passes) the kilometer posts and special points. It is then possible to determine the exact speed of the train between two posts, the exact point where a shock has been felt, and to see if this point corresponds with any apparatus in the track, such as a frog, switch, etc.

The apparatus used is shown in Fig. 1. The two vertical pendulums A A oscillate on shafts B B, and strike against the central frame C C, which is made in two parts to prevent the transmission of shock from one pendulum to the other. The springs D D, whose tension is regulated by set screws E, reduce the travel of the pendulum. The oscillations are recorded by the pens F. At the upper part are two horizontal pendulums G G oscillating around shafts H H, held in equilibrium by the springs J J, and striking against the frame K. As the shocks are very slight only a single frame is used. The recording is effected by the pens L L, which are carried by levers balanced on fixed axes, so that they are not affected by lateral shocks. A pen M, operated by a rubber bulb by hand, marks the kilometer posts, stations, tunnels, etc. The mechanism for feeding the roll of paper consists of a magazine roller N; a collecting roller O, operated by a spring, and a regulating roller P, controlled by an escapement. The screws Q are for attaching the apparatus to the table in the car.

In the interpretation of results, especially those of the lateral shocks, it is necessary to remember that the car does not follow exactly the course of the track. Consequently, certain defects (especially slight irregularities in line) may more or less escape being recorded; but this applies to all parts of the line, so that the general record is sufficiently exact. On the other hand, it may be taken for granted that every slight shock recorded corresponds certainly to a defective point in the track. In several cases when the section foremen have failed to at once find the cause of certain shocks reported to them after an inspection, they have been ordered to make a more careful examination, which has brought the cause to light, thus showing the value of the records.

After several trips on a certain piece of line at different speeds the limit of admissible oscillation is determined and is marked on the charts. In passing curves, the lateral oscillations are made more difficult of interpretation, as the speed not only increases the intensity of the shocks, but also falsifies the records given by the apparatus,

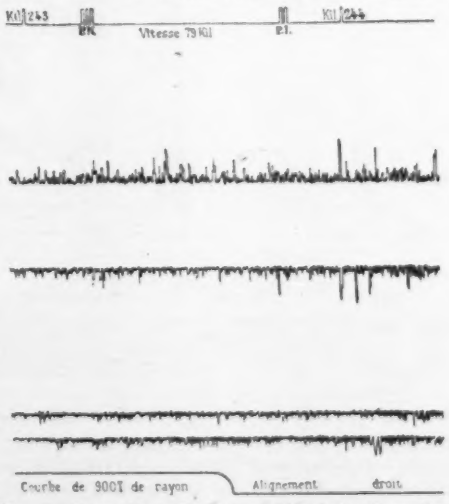


Fig. 3. Inspection Record of Track in Poor Condition.

the pendulums having a tendency to move by centrifugal force. A sufficiently exact determination, however, can be made by watching the motion of the two pendulums. If their oscillations appear to be equal it may be assumed that the effect of centrifugal force is balanced by the superelevation and that the records can be taken as equivalent to those on straight lines. If, on the other hand, the oscillations appear to be greater towards one side or the other, it may be presumed that they are increased by the inclination or the centrifugal force, which must then be taken into account in interpreting the results.

Fig. 2 is an example of a record on good track, and Fig. 3 is an example of a similar record on track in poor condition, both sections of track being laid with 60-lb. rails 25 ft. long, with 11 ties to the rail. The speed is the same in both cases,

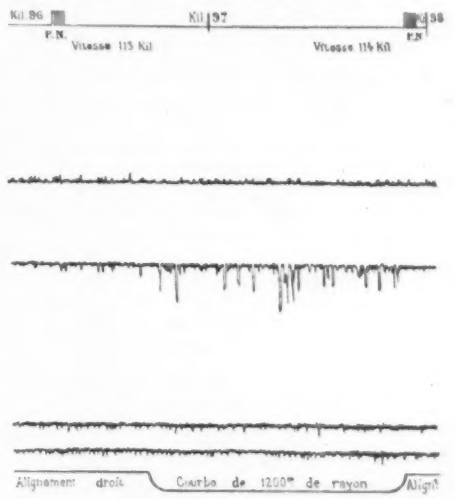


Fig. 4. Inspection Record of Track on Curve, Showing Influence of Centrifugal Force.

46 miles an hour. Fig. 4 is a record in which the lateral indications are exaggerated by centrifugal force on a curve. This record was made on 90-lb. rails 39½ ft. long, with 16 ties to the rail length.

All the lines carrying high-speed traffic are usually inspected at the beginning of the season. The charts are examined, compared with those of previous inspections, and then sent to the roadmasters, calling their attention to points where the condition is not satisfactory. This enables them to concentrate their work where it will best facilitate the traffic, and the charts are then returned to the maintenance-of-way department with an explanation of the nature of the defect corresponding to each point indicated, and the steps taken to remedy it. Special inspections are also made, as, for instance, when complaints are made of shocks or hard riding of trains on any piece of line. This system has been found very advantageous.

A NEW DESIGN OF TRUSS WITH PIN AND RIVETED CONNECTIONS.

In the design of truss bridges there is a growing tendency to dispense with pins and use riveted connections, except in cases where the pin-connected type of construction presents its special advantages. The accompanying cuts represent a radical departure in truss design, in which both riveted and pin connections are employed. This type of truss was developed by Mr. J. W. Schaub, M. Am. Soc. C. E., 1650 Monadnock Block, Chicago, who has been using it since August, 1901. It has been adopted by Mr. E. Fisher, Engineer of Bridges and Buildings of the Missouri Pacific Ry.; Mr. H. G. Kelley, Chief Engineer of the Iowa Central Ry., and by Mr. C. D. Purdon, Chief Engineer of the St. Louis & San Francisco Ry. For all of these Mr. Schaub has prepared plans for bridges as Consulting Engineer. The particular bridge illustrated is one for the St. Louis & San Francisco Ry.

It will be noted that the truss is of a Warren type, with a combination of pin and riveted connections; the bottom chord is entirely pin-connected, while the top chord has pins only in the end joints. The web members are partly pin-connected and partly riveted. The design is claimed to present many advantages over the usual forms of pin-connected spans, and serves as a link between the short riveted spans (under 150

ft.) and the long pin-connected spans (over 200 ft.).

The salient features of this design as outlined by Mr. Schaub are as follows:

(1) The absence of all adjustable members.

(2) Truss members subject to a reversal of stress are riveted at their connections, which permits of no movement on the pins during the change from one kind of stress to another.

(3) The top chord being riveted throughout permits of no articulated joints, which is a very important consideration in case a derailed train should knock out an intermediate post.

(4) Facility in erecting the main trusses with a derrick car or a traveler. After the floor system is in place, the web members are raised, one at a time, and bolted to the floor beams. The top chord sections are placed in position last; and at no time is it necessary to hold up more than one truss member to make any connection in the field. It is true that the field work costs more, as compared with the usual pin-connected designs, but this is due to the field riveting.

(5) Economy in design, owing to the narrow limits to which the top chord can be confined, making the entire bridge narrower, in addition to making the top chord sections themselves narrower, as compared with pin connections. The saving in weight in the main trusses is about 3% for a 150-ft. span.

The bridge illustrated carries the St. Louis & San Francisco Ry. over the Meramec River, and consists of two through spans of 153 ft. 4½ ins. The trusses are 30 ft. deep and 15 ft. 8 ins. apart, c. to c. The general design and composition of members are shown in Fig. 1. The track stringers are plate girders with web plates 38¾ × ⅜ ins. and four angles 5 × 3½ × ½ ins. The floor beams have

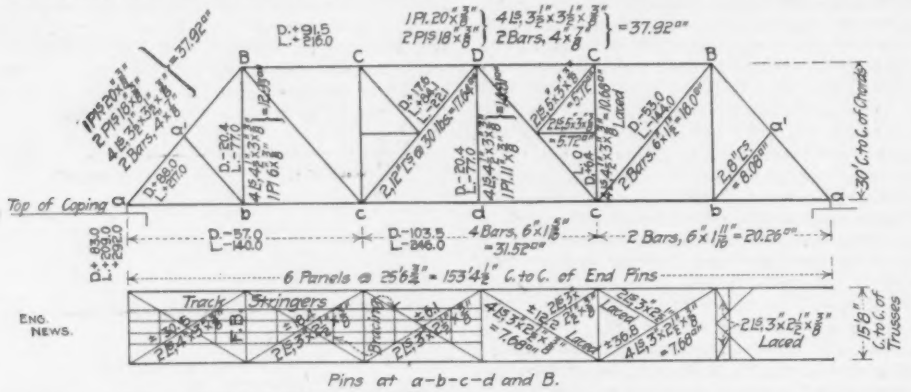


FIG. 1. TRUSS WITH COMBINATION OF PIN AND RIVETED CONNECTIONS; ST. LOUIS & SAN FRANCISCO RY.

J. W. Schaub, M. Am. Soc. C. E., Consulting Engineer, Chicago, Designer.
C. D. Purdon, M. Am. Soc. C. E., Chief Engineer, St. L. & S. F. Ry.

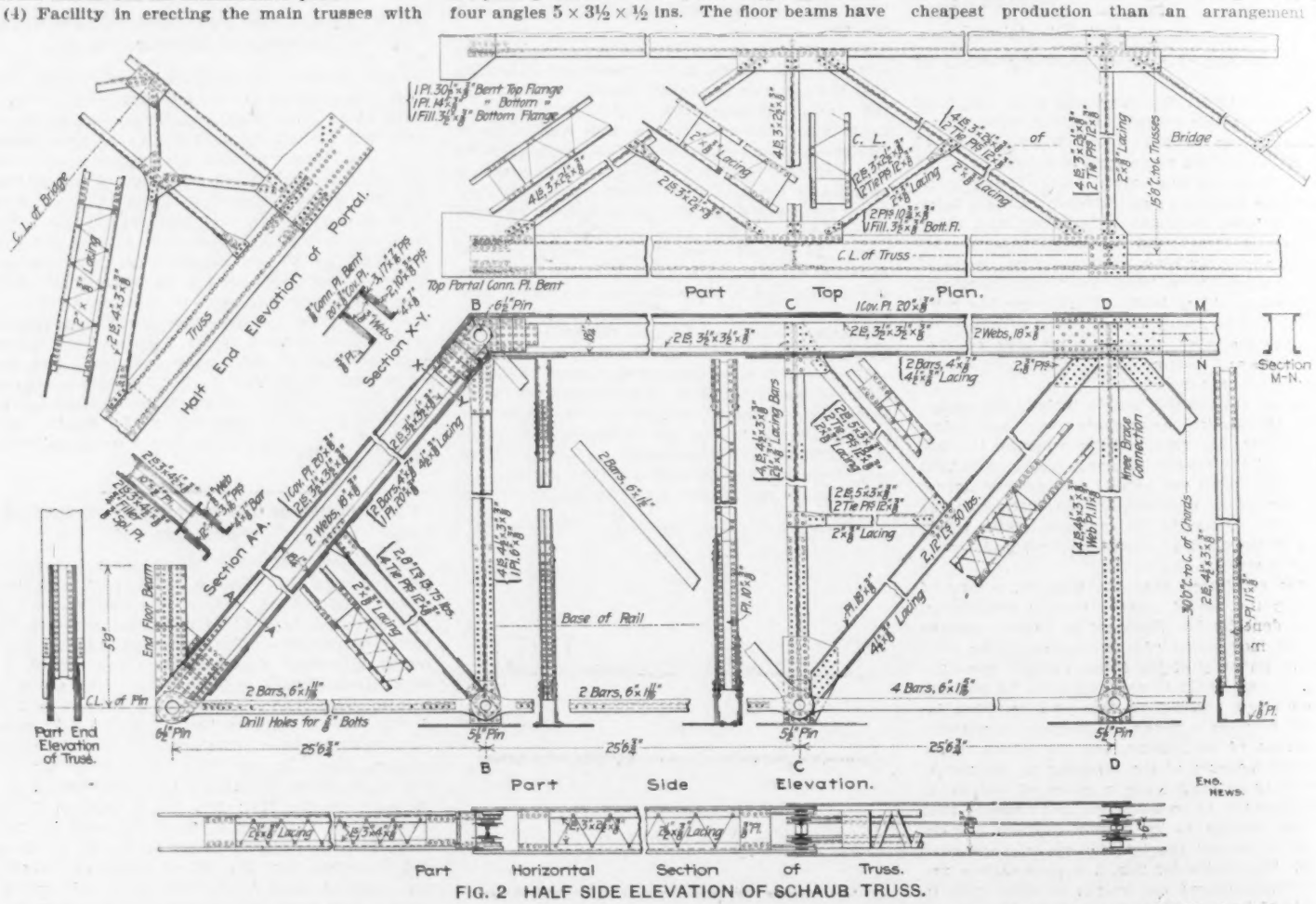


FIG. 2 HALF SIDE ELEVATION OF SCHAUB TRUSS.

web plates 47 × ½ ins. and four angles 6 × 6 × 13-16 ins. The material used is soft steel, except that medium steel is used for eyebars, pins and rollers. The assumed dead load is 2,100 lbs. per lin. ft. (465 lbs. for track). The assumed live load consists of two consolidation locomotives (Cooper's specifications, type E-40), followed by a train load of 4,000 lbs. per lin. ft. The maximum moment and end shear in track stringers and floor beams are as follows:

	Track stringer ft.-lbs.	Floor beam
Maximum moment	175,500	
Maximum end shear	31,000	

The details of construction of the truss are shown in the half elevation, Fig. 2, and the cross-section, Fig. 3.

THE PLANNING OF FACTORY BUILDINGS AND THE INFLUENCE OF DESIGN ON THEIR PRODUCTIVE CAPACITY.

By Hugo Diemer.*

In designing factory buildings, considerations of utility and economy must come first, and architectural effects must subserviently adapt themselves to these prime requisites. The building must be designed with regard to intake and output, adapting the arrangement to the equipment and flow of work, following always the lines of least resistance as regards both losses in transmission apparatus and losses in activity of live operators.

It must be evident that a wide variety of output cannot be advantageously built in a single shop. It sometimes happens in the machine-manufacturing business that a single shop must, on account of trade conditions, manufacture both light and heavy machinery, or machinery and light detail fittings. In such cases careful planning of departmental arrangements, equipment, and organization, is particularly necessary, to keep the separate costs of production of each type distinct, and at a price reasonably near the minimum for each class. Again, it has been found that the building of groups of parts representing a complete organ of a machine, in a single department, is often more likely to bring about the cheapest production than an arrangement in which all pieces travel through the whole shop, each distinct class of machine-tool work being grouped by itself.

The proper arrangement of departments, and of machines, with regard to each other, depends on statistical knowledge of the predominant paths of travel of the material in process of manufacture. Such information collected by actual ob-

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servation can alone determine to the best advantage, also, the location respectively of rooms for stores, stock, tools, grinding, etc.

Except when specific reasons to the contrary appear, the cheapest building is to be constructed in which it is physically possible to do the work well. A building must provide shelter from weather, afford good light and ventilation, and must be able to resist all strains to which it is subjected by equipment and employees, besides offering reasonable resistance to weather and conflagration. Beyond these considerations any additional elaborations are only excusable when charged to the advertising account.

For psychological reasons it is desirable that the building present a pleasing appearance. Hence, any architectural artifices are to be commended that will relieve monotonous continuity, such as in the case of a long building, the use of projecting pilasters which also add to the rigidity of the structure, or the use of external projections for elevator shafts and stairways, if such a location be desirable. Where a low building with central gable and single gallery is used, it may be desirable to have elevators and stairways at the inside of the gallery on account of

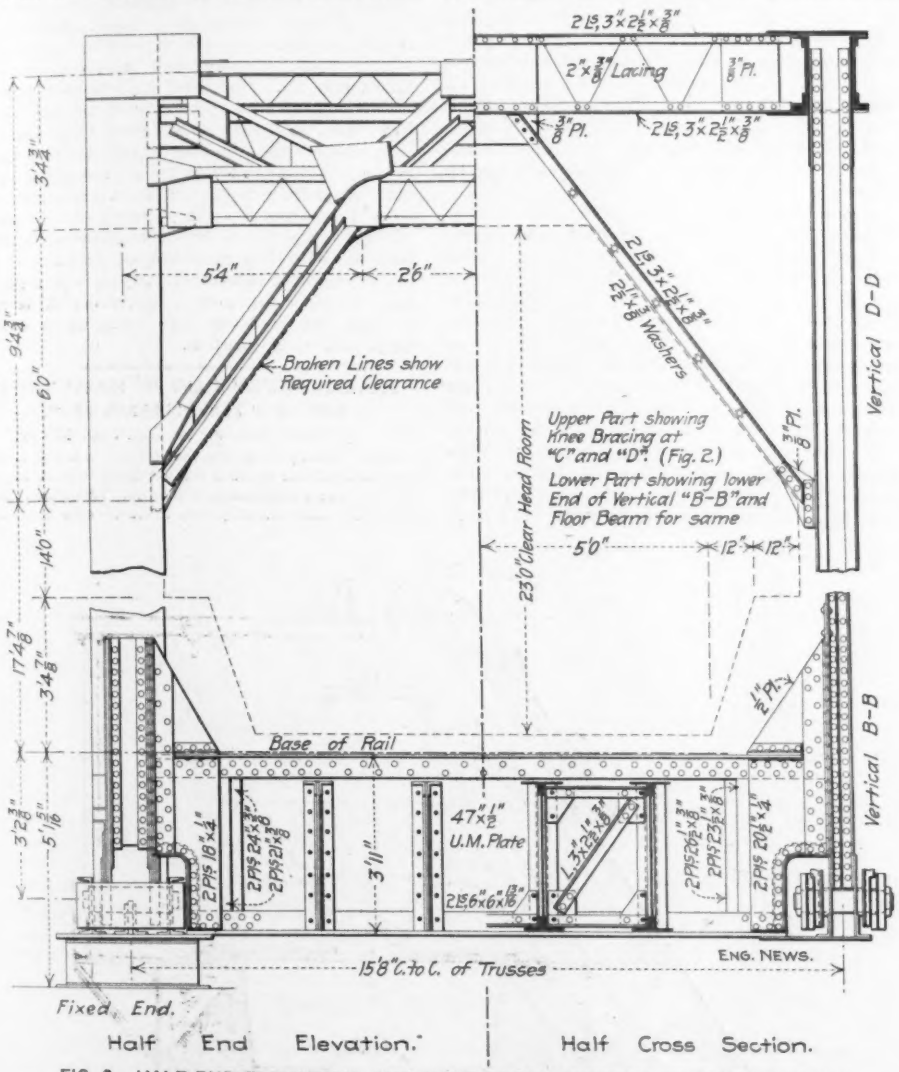

FIG. 3. HALF END ELEVATION AND HALF CROSS-SECTION OF SCHAUB TRUSS.

their thus feeding a wider territory with a shorter amount of walking and hauling than they would if placed at the outer walls.

It is important that as great floor space as possible should be visible at all times. Hence, all angles, "L's," "E's" and "H's" should be avoided in favor of the plain, long, rectangle. The same consideration of visibility and the avoidance of unnecessary walking or elevator riding, argues for the single-floored structure as against multi-floored buildings. Even the single gallery is best avoided, as it forms a more or less isolated area not readily visible, and increases walking and trucking. "Avoidance of unproductive travel" demands a minimum of passage ways, which passages should always be under the close supervision of watchmen who must note all wandering clerks and workmen, and who must be so informed as to the employees and their duties, that they may be able to observe and report illegitimate or aimless wandering.

The single-floored building is often to be preferred even where land is costly. The lower cost of the building, the reduced fire risk, and above and beyond all, the greater productivity per unit of floor area, may more than counterbalance the interest on the first cost per unit of floor space. Moreover, a large tract of well-located land is bound to rise in value.

The site selected as well as the shape of the building, must be such as to allow for expansion. This demands the possession of land allowing for the expansion in length of the rectangular building, and such lateral expansion in the way of additional buildings, as may in time be needed.

A well designed building will provide facility for enlargement, maintaining the same balance of floor area. This demands the recording of all increases of area whenever they have become necessary, and the use of such data in designing new buildings. It has been aptly stated that a well-designed factory building or set of buildings should be as flexible and adaptable to enlargement as the "unit" system of filing cabinets.

The departmental organization of an establishment should be carefully analyzed and if necessary, revised, before a new building is erected. The location of departments so as to secure minimum travel, demands careful study, as does also their arrangement to secure the easiest flow of work without interference of currents.

The proper location of the rooms for raw material, partly finished material, finished parts, finished complete stock, wash rooms, lavatories, locker rooms, tool room, grinding room, etc., should not be deferred until after a plan has been adopted, since their proper location will have a decided influence on the cost of production.

In the shop portions, room must be provided, without crowding, not only for all machinery, but for all materials in process of manufacture. Sufficient room must be allowed to provide convenient access to all parts of a machine, and for the removal of any machine whenever necessary. Sufficient area must be given for the storing of as large a supply of working material and finished material as may be necessary, without interfering with the passageways. The open areas must be wide enough to permit the passage of two trucks in the aisles and for the sidetracking of trucks around machines. A good truck system includes many more details than the providing of occasional turntables. A truck system involving the retention of the material in the trucks, with as little unloading and reloading as possible, and with as little hauling of empties as possible, is an important feature, and one deserving attention in any establishment. It involves the building of a considerable number of trucks, and departmental supervision, but is likely to result in economy.

A noticeable defect in the great majority of factory buildings is the large amount of vibration. A careful study of the uses to which the building is to be put, and the location of its equipment, could almost wholly prevent this defect, whose evil results are far greater than is generally appreciated. Vibration causes undue wear and tear of machine tools, and interferes with correct tool work, besides seriously affecting the efficiency of all employees, whether they are engaged at manual or mental work. Here again the folly of adopting some architect's "ready-made" plans become apparent. Too often the designer's knowledge of the work to be done in the factory is practically nil.

The wind loads and snow loads are wholly secondary to the live stresses due to shafts, countershafts and moving machines. Economic production demands that the building fit the machinery, whose location in turn, as previously stated, depends on the flow of the work. Liberal foundations are to be provided for all heavy machines. A cushion of asphalt below and around the foundation has been used to good effect as an additional vibration destroyer.

Economy demands the location of the source of power and heat at the side of the building, somewhat nearer the end which is likely to be elongated. It should be provided with easy means of access for delivery of fuel and for removal of ashes. The use of sloping trestles is often an advantage in bringing cars to the level of upper floors or platforms in the case of power-plant, foundry, etc. A system of out-door tracks and of out-door cranes should be considered and provided wherever, on investigation, it would appear to be an economic move.

The general form of the framing of the building designed to conform with the ideas suggested will not include many varieties. It may have the central gable with sloping sides, the central gable with saw-tooth construction on the sides, or the entire shop may be of the saw-tooth roof construction. The central gable gives a more pleasing architectural effect than the saw-tooth roof over the whole building.

It is not the aim of this article to take up such features of building construction as have not directly to do with the productive output; hence, it will be unnecessary to treat of such matters as materials for roof covering, framework, side walls, painting, etc.

In designing a building it must be borne in mind that while it must be so planned as to place to greatest advantage the machinery of manufacture, there will always be a great deal of work that depends upon human attendance, and that it is just as important that the human machinery be provided with such surroundings and arrangements as will make it the most efficacious. Such arrangements are too often looked upon as philanthropic or advertising measures, when in fact, they are part of the productive equipment. The output of man, as a machine, is regulated first

of all by the amount and quality of fuel or nourishment supplied as food and air and heat. Poor air and insufficient light and warmth inevitably result in poor work as regards quantity and quality, even though the workers may be picked for their cheerful and sunny dispositions. Agreeable and healthful surroundings will tend more than anything else to make workers contented; and discontent in a factory organization at the present day is sure to lead to trouble. Hence, it becomes important to consider what features of building construction influence comfort.

Many of the factory floors in use are responsible for much discomfort. The wood floor is the only one that is conducive to comfort since wood is a poor conductor of heat. Hence, the wooden shoes worn in many cold and earthen-floored foreign shops, the object being to keep the feet less cold. A wood surface, even on concrete floors, is advantageous for other reasons than those of comfort. The dust from concrete floors is injurious to machined surfaces. Moreover, a wood floor furnishes a good grip for bars used in moving heavy castings, machines, etc. Short lengths of maple, even of poor grade, are to be preferred to softer woods for flooring. The short lengths facilitate repairing. For heavy machines and on testing floors, metal floor plates with "T" slots, sunk in concrete, have been advantageously used. Asphalt or coal tar on top of concrete prevents the rise of moisture through it to the hardwood top. The most satisfactory ground floor is constructed with steel I-beams laid in concrete, with asphalt moisture-proof coat and hardwood surface.

With regard to heating and ventilating, it can safely be said that the loss in labor efficiency and consequent output per man will certainly be found to be enormously greater than the cost of proper heating and ventilating facilities. The heating of most factory buildings is accomplished by direct radiation, using the exhaust steam of a non-condensing engine either as complete or auxiliary heating medium. In many cases the heating system has been very carelessly put up, without any plans or specifications having been prepared for it. As a result the radiating surface is often insufficient or poorly balanced, and the circulation defective. A system of steam heating should always be planned by a competent mechanical engineer. Owing to the very long pipe lines necessary in factory buildings of the modern type, direct radiation systems for factories, even when designed by competent engineers, are likely to be troubled with poor circulation, and to be slow in action in cold days. The indirect system of heating air in heating chambers supplied with steam coils, and delivering it under pressure from a blower, possesses the advantage of heating a shop much more quickly in the morning, and of more uniformly distributing the heat, so that although the cost of total heat units delivered may be higher than with the direct radiation system for the same number of heat units, still the cost of effective heat units will be less. The tremendous gain derived from comfortable workers will far more than counterbalance the additional cost of operation using the indirect pressure system, as compared with direct radiation. This system is by far the best from sanitary considerations. The pressure is always outward, hence there is a freedom from drafts and an avoidance of the accumulation at the top of the building of the total radiated heat, as is so apt to be the case with the direct radiation system. The cubical contents of most factory buildings are so large that sufficient number of changes of air per hour are secured by drawing only a portion of the air for circulation from out of doors, so that the expense of the indirect pressure system when applied to factories can be made a good deal less than that of the same system as applied to public buildings, where the cubic space per person is many times less, and the number of changes per hour must be much more frequent. Of course, if the air in the shop is vitiated by the processes of manufacture going on, the foregoing remarks will not apply. It will always prove economical to provide pure air. This is true of a factory located in unsanitary surroundings, in which circumstances it will be profitable to provide air shafts of considerable height to draw in pure air.

Abundance of light is as important as abundance of pure air. Natural light should permeate the whole shop during all hours at which it prevails out-of-doors, and not only work-benches and machines, but stairways and all passages should be light. The saw-tooth roof with glass portion towards the north, gives the most agreeable and diffused light. Skylights are undesirable on account of breakage and their obstruction by snow. In the case of the saw-tooth roof, clear window glass may be used, since it is never exposed to the direct rays of the sun. Windows in the ventilating portion of the central roof gable will need shades, unless made of ground glass. As to the side windows, they are exposed to direct sunlight if there are no closely adjacent buildings. Shades usually receive rough treatment in a shop, and are certainly short-lived. If the nature of the work is clean enough to permit of their use, buff color is recommended, since this variety does not shut out too much light. The adjustment of shades is likely to cause quarrels among the shop hands, however. Ground glass panes have been adopted in a few cases, and answer very well to keep out direct sunshine. In one instance their use created trouble because they interfered with the view out-of-doors and were considered offensive by the type of workman who always carries a chip on his shoulder, although he probably came from a shop whose windows were opaque with the accumulated grime of years. Prismatic glass has been used to advantage in places where the light is shut out by high walls.

As to artificial light, there is but one kind to be considered in a modern establishment having its own power plant, and that is the electric light. As wide fluctuations in the load of electric generators are accompanied by low efficiencies, it will be generally advisable to have a distinct engine and dynamo unit for lighting purposes. Arc lamps on the incandescent circuit are desirable for general illumination, accompanied by incandescents for individual machines and benches. Good light demands that the wiring be of ample size to prevent drop enough in voltage to produce any dulling of lamps. The threaded base and socket are most generally used. It has been claimed, however, by some large users of lamps where there was much vibration, that the lamp with spring base and socket is less likely to wear loose. Wire guards should not be used on lamps excepting where really needed. Their cost and interference with light renders it doubtful whether they are any real saving. For delicate work the so-called "tipless" incandescent lamp provides the most perfect illumination, being free from the circles of darkness that are cast by lamps sealed at the bulb end. Some provision, must, of course, be made for artificial illumination when the power plant is shut down, by connection to a public electric or gas circuit, or if this is not available, by a stock of oil lamps for emergency use.

Too much stress cannot be laid on the great importance of the absolute fireproofing of such parts of buildings as are intended for the reception of the almost unreplaceable requisites of manufacturing, such as drawings, patterns and inventory. Drawings and patterns of tools, jigs, etc., are too often carelessly treated since there may be but one article completed from them, but their loss in case of destruction of the tools by fire would be enormous.

Lockers and wash rooms should be so planned that thorough discipline and system can be maintained with regard to them. Good discipline and system in these incidental features is bound to react on the work of the shop as a whole.

Outside of the locker and wash rooms, the only portions of the shop which it is desirable to have partitioned off and not subject to visibility, are such departments as need isolation on account of the work to be carried on in them. Such departments are those devoted to rattling and cleaning of castings, polishing and grinding, painting, japanning, etc. But these departments must not be so isolated that their supervision will be any less close than that of the shop as a whole.

It must be apparent on consideration of the influence of the building as a productive factor, that, aside from the specifications covering materials of construction, the planning of the building is best undertaken by a mechanical engineer familiar with the processes of production, who will provide the structural designer with a general plan of the requirements, together with data regarding the dead and live loads to be encountered, and their location.

STOCK DISTRIBUTION AND ITS RELATION TO THE LIFE OF A BLAST-FURNACE LINING.*

By David Baker,† M. Am. Inst. Min. E.

When the skip hoist was first tried as a means of filling the blast furnace it made a great many enemies and very few friends among furnace managers. This state of affairs continued until the Duquesne furnaces were built, which demonstrated not only the possibilities of a furnace stack in the way of production, but also the ability of the skip hoist to charge the materials necessary to produce the large tonnage obtained. Every furnace manager who has

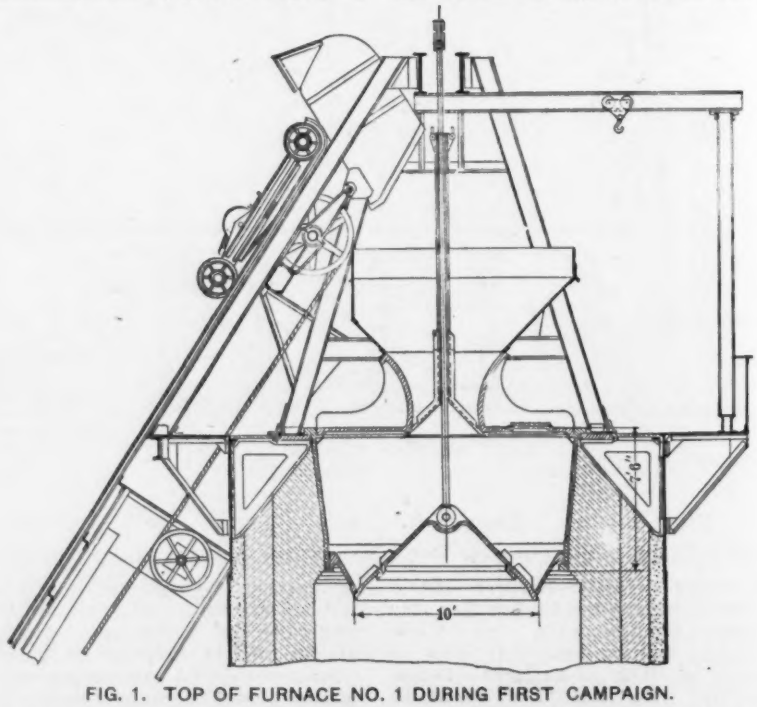

FIG. 1. TOP OF FURNACE NO. 1 DURING FIRST CAMPAIGN.

*A paper read at the Atlantic City meeting of the Am. Inst. Mining Engineers, February, 1904.

†Gen Mgr., Dominion Iron and Steel Co., Ltd., Sydney, Nova Scotia, Canada.

operated stacks fitted with the vertical hoist and the hand-barrow system of filling remembers that the momentous question about the furnace, particularly during a good run, was: "Are you keeping her full?" and many a good run has been spoiled by the furnace "getting away from the men."

With the new birth of the skip hoist this trouble was alleviated, but alas! Other and more important difficulties arose. The distribution of the stock, the importance of which is never learned until many different ores and fuels have been tried, demanded closer attention. With all the defects of the hand-barrow system, the distribution

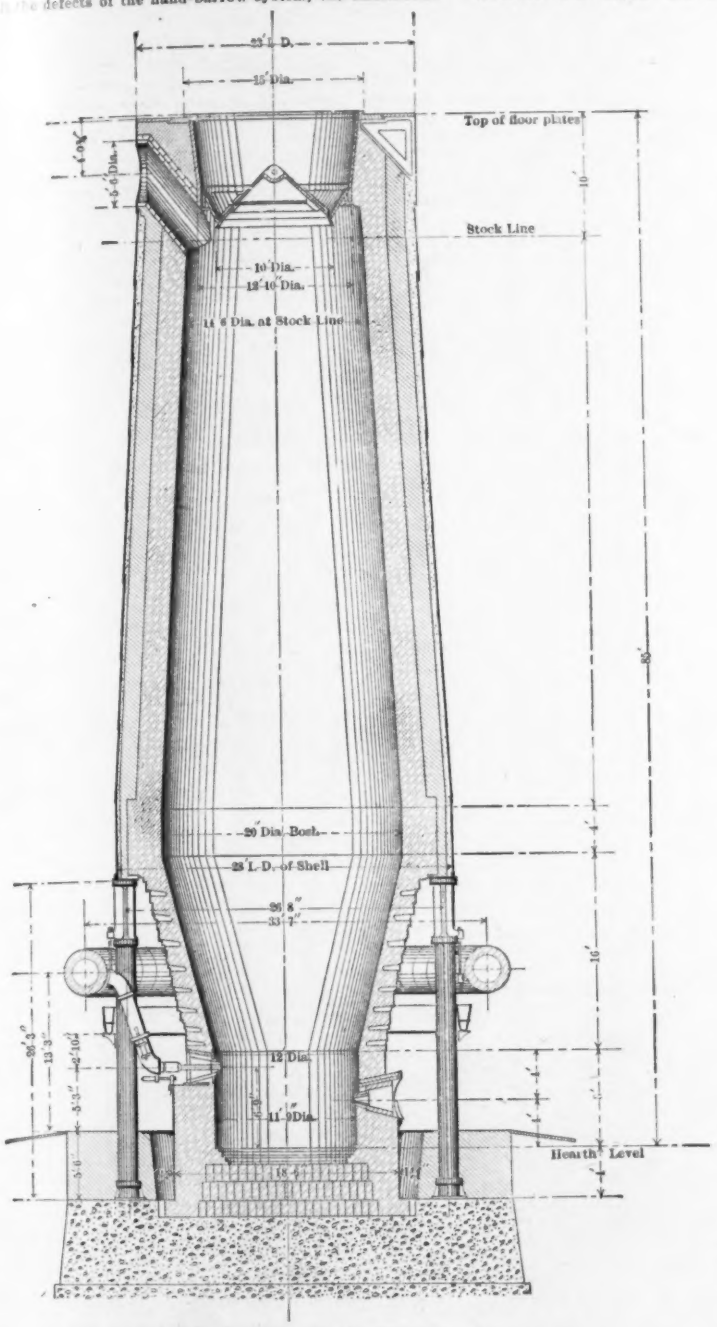

Fig. 2. First Lining of Furnace No. 1.

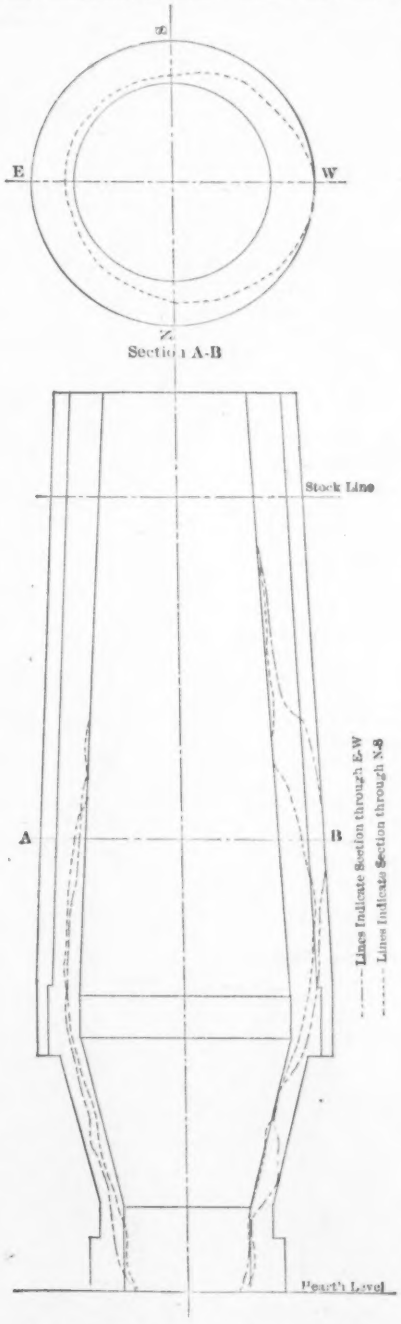

Fig. 3. First Lining of Furnace No. 1, "Burned."

—when the top fillers were conscientious in carrying out the filling scheme arranged after thoughtful consideration by the manager—was above criticism. It is said that the modern skip hoist, equipped with an elliptical hopper and receiving cylinder, and discharging over a small bell into the main hopper, will give just as good results as those obtained with hand-barrow charging, but I can not agree with this statement. I grant that, under very favorable conditions, the mechanical furnace top will do apparently as well as the hand system of charging, but under unfavorable conditions it fails. It is the unfavorable case that is all important, for that frequently means the success or failure of the business concerned.

I am now speaking from my own experience. Possibly there is in the market to-day a mechanical top charger that will give as good distribution as that obtained by the hand-barrow system, but the low fuel consumption obtained by the furnaces equipped with the old system has never, to my knowledge, been equalled by those with the new. Can any one point to such a record by a new plant as that reached by Furnace No. 6 of the Illinois Steel Co., which showed for a year a fuel consumption of 1,581 lbs. of coke per ton of pig iron produced?

I believe the reason for this lies in the great abuse to which coke is subjected in these new plants. I refer to the great number of times the coke is required to drop from one receptacle to another, grinding much of it into dust, and breaking the balance into pieces much smaller than those of the original coke freshly drawn from the oven. It is quite common at such plants for the coke to be forked into hopper cars at the ovens, dropped from these into a deep steel bin at the furnace, drawn into the larry car, dumped into the skip, thence into the top receiving hopper, from which it drops on to the main bell, and is finally discharged into the furnace. Other modern plants avoid one dump by chuting the coke direct from the bins to the skip cars. On the face of it this seems to avoid one handling and to save a great deal of breakage, but usually these bins are so much deeper than those in connection with the larry that the breakage is nearly as great.

By this mechanical system the coke is dropped from six to seven times as compared with three or four times by the hand-barrow system, and one of these (from the barrow into the furnace hopper) can hardly be called a drop, the breakage resulting therefrom being so slight.

Many of my readers have seen what, ten years ago, might have been called a modern plant, equipped with hand barrows which take the coke direct from box cars into barrows; in this system the coke receives practically only one drop that is likely to cause any breakage, i. e., when it is discharged from the bell into the furnace.

This careful handling of the coke is of the utmost importance, and when the coke is of a soft or friable nature, it may mean the difference between the success and the failure of the blast-furnace operation.

The baleful results of the breakage by the repeated handlings of coke in the modern furnace plant equipped with the usual mechanical charger, as well as the necessity of obtaining good distribution of the stock, were demonstrated very clearly at the plant of the Dominion Iron & Steel Co., at Sydney, Nova Scotia.

The coke, made in the Otto-Hoffman by-product ovens, about 1.5 miles from the furnace plant, is delivered to the furnaces in hopper cars each of 20 tons capacity, and is dumped from them into large coke bins at the foot of the skip hoist; thence it is drawn direct into the skip bucket.

The hoist is a double-skip arrangement, and the top charging device, shown in Fig. 1, consists of a circular hopper, having the discharge controlled by a small bell.

The coke used at this point is made from the Dominion Coal Co.'s coal, and is very friable and quite soft.

The first furnace was blown-in on Feb. 4, 1901, very successfully, and everything worked smoothly for a few weeks; but, at the end of this period the furnace began to hang and slip and burn tuyeres, sometimes cutting at a slip every tuyere in the furnace. The tuyeres failed in nearly every case on the lower side of the nose, showing that they must have been flooded by cinder and iron when the slip occurred. The destruction was so rapid that, in some cases, the tuyeres exploded, blowing down the "blow pipes" and the "penstocks," causing a panic among the furnace men and not adding to the comfort of the furnace manager.

An analysis of the flue dirt gave the following results, which show that most of it was coke: Loss on ignition, 52.87; SiO_2, 8.60; Fe_2O_3, 16.35; Al_2O_3, 0.56; CaO, 5.51; and MgO, 3.40%.

The coke in the bins was very dirty and badly broken, and it was apparent that the coke in the hearth of the furnace was so finely divided that the slag found great difficulty in settling through the mass, particularly during a slip; hence, the flooding of the tuyeres with cinder and iron, and their consequent destruction.

In fact, it was only after long blowing at the cinder notch and repeated checkings of the blast that the tuyeres could be dried sufficiently to take off the blast without filling the blowpipes.

The first effort made to reduce the tuyere destruction was the increase of the feed-water pressure by changing from the regular tank service of salt water at 20 lbs. to the fresh-water main at 40 lbs. per sq. in. This made only a slight improvement.

Next was the steady increase of the number of engine revolutions, until an average volume of 36,000 cu. ft. per min., measured by piston displacement, was forced through the tuyeres. After this change the slipping was less frequent, the output greater and, at the same time, no more tuyeres were lost.

Finally, silica rock was introduced in the charge, which had a marked effect, making the slag very fluid, reducing the burning out of the tuyeres materially and increasing the output greatly. The best results were obtained by the addition of 200 lbs. of quartz gravel for each ton of ore charged, changing the slag analysis from 31.54 to 34.32 SiO_2, and from 15.2 to 12.76% Al_2O_3. At that time dolomite was used as a flux.

The ore obtained from Wabana, Bell Island, Conception Bay, Newfoundland, is a uniform, dense, red hematite, which has been split up *in situ* by cleavage planes into lumps of rhomboid shape, having a similar appearance to broken red brick.

The ore is practically free from fines and is of the following average analysis: Fe, 51.43; SiO_2, 14.03; Al_2O_3, 4.57; MgO, 0.52; CaO, 2.23; Mn, 0.15; P, 0.805; S, 0.038; and TiO_2, 0.45%.

The high percentage of alumina in the ore seems to render the slag viscous, and is only corrected by the addition of silica, the best results being obtained when the slag does not exceed 13% alumina. Probably the titanic acid also adds considerably to the infusibility.

Notwithstanding all the changes noted above, which lessened the destruction of the tuyeres, there was still room for much improvement. Screens were placed in the chutes from the coke bins to the skip buckets, which eliminated 4% of fine coke braize.

These changes had hardly been accomplished when the shell of the first furnace began to show an unusual temperature about 20 ft. from the top of the bosh and opposite to the skipway. The furnace had been in blast only six months, and the bricks, made by Harbison & Walker, of Pittsburg, Pa., were held responsible for this rapid failing of the lining. It was stated by those present when these linings arrived that the bricks had not been properly housed, and had been subjected to freezing after being wet. Fig. 2 shows the first lining, in which the bricks used in backing up the in-wall were of second quality Scotch make. The burned lines of this furnace, Fig. 3, shows that the failure of the in-wall was confined to the side opposite the skipway.

The second furnace started, No. 2, five months after the blow-in, developed the same weakness in identically the same place.

From the first I doubted that the bricks were wholly responsible for these failures; and when the third furnace, after a most favorable start, with all the conditions normal, developed a hot spot within three weeks after blow-in, and cut through nearly 5 ft. of fire-brick in exactly the same location, I was convinced that the true cause of the trouble should be sought in another quarter. The condition of the coke charged and the distribution of the charge had been carefully studied for some time, and it became evident that they had some connection with the irregular wear of the furnace in-walls.

When the first lining failed, a model furnace was prepared with a complete top-charging arrangement, the shell being of glass strips fastened to narrow wooden strips, so that the descent of the charges could be observed. The material was drawn from the bottom so as to lower the stock in the same way as the blast-furnace charge is moved by the combustion of the coke in the hearth. At the same time a careful study was made of the actual filling at the furnaces in operation.

The result of this observation showed that the furnace hopper was filled in the manner illustrated in Fig. 4; the finer portion of the charge remained under the dumping point of the skip, while the coarser portion of each material rolled to the other and the same side of the furnace where the lining had failed in every case.

The furnace, therefore, had on one side the best coke and all lump ore and flux, while on the other side was the coke dirt and fine coke with the finer portion of the ore and flux, which latter material had been crushed at the quarry to pass through a 4-in. ring. As a result of this condition the furnace worked faster and hotter on the side having the most lumps; in fact, it was "channeling" in that direction. Had the charge been of regular Lake Superior ore, with about 10% lump material, and Connellsville coke, probably no such separation would have been noticed, for there would have been enough fine ore to have made the charge practically of the same penetrability to the upward-moving gases, and very much less breakage of fuel, so that in efficiency the whole charge would have been more nearly the same.

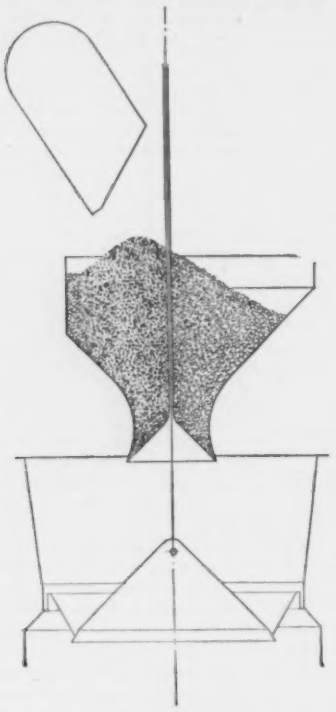

Fig. 4. Ore Distribution in Furnace No. 1, First Campaign.

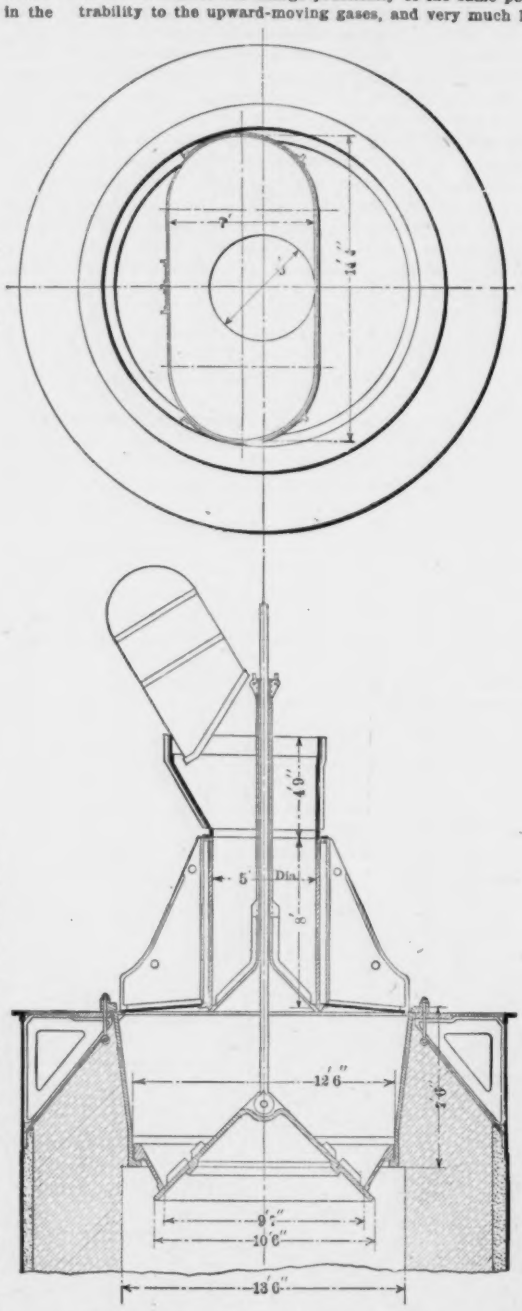

Fig. 5. Top of Furnace No. 2, Second Campaign.

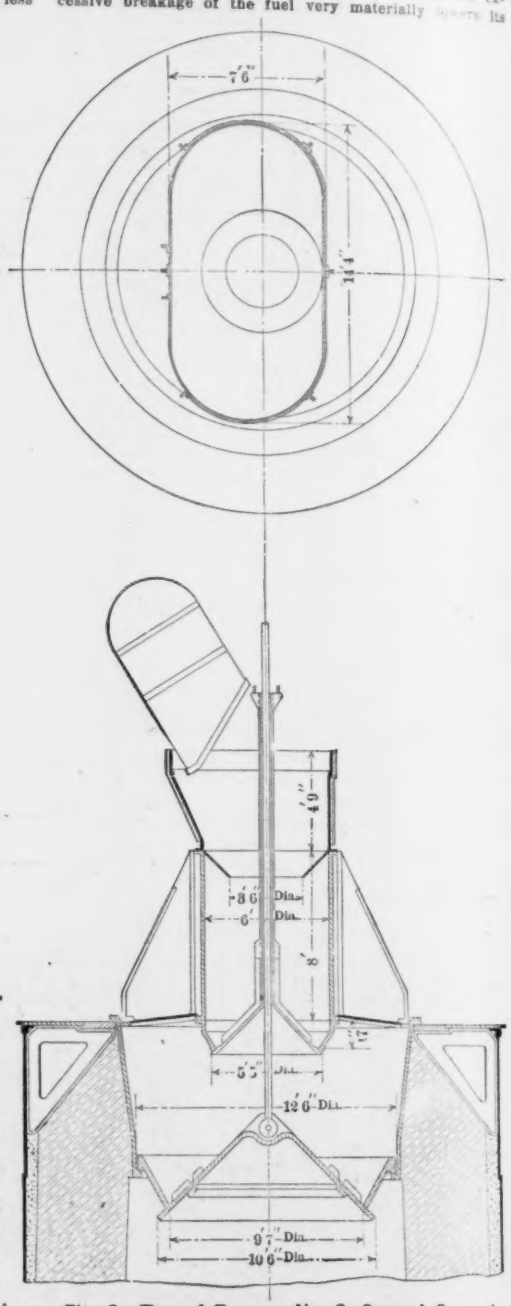

Fig. 6. Top of Furnace No. 3, Second Campaign.

In order to correct these defects of distribution, a top for Furnace No. 2 was designed,* as shown in Fig. 5.

In this new furnace top an elliptical hopper replaced the old circular one, the idea being to prevent the sizing of the material by discharging this elliptical hopper into a cylinder closed by a bell. The head frames of the top were so low that the cylinder could not be made as long as was desired, and it did not have quite the capacity of two full skips. Four months after the "blow-in" this furnace developed a hot spot, on the side opposite from the others, which apparently showed that the sizing had been reversed, but not corrected.

The second attempt to correct the distribution without entirely removing the head frames and changing the angle of the skipway is shown in Fig. 6.

In order to make room in the cylinder for two full skip-loads of coke, the diameter was increased to 6 ft., and the lower part of the elliptical hopper was extended into the cylinder, thus narrowing the opening to 3.5 ft., so as to throw all of the material to the center of the cylinder and in the sizing, which must inevitably take place, to leave the fines in the center and the lumps next to the shell of the cylinder. This furnace has now been in blast 18 months and has not shown any unusual heating in the shell.

The breakage of the coke continues and can not be remedied with such a filling system, but enough has been done to show that with well coked, washed coal a fairly uniform furnace practice can be maintained with only the normal destruction of tuyeres. Unquestionably the excessive breakage of the fuel very materially lowers its practical calorific efficiency in the blast furnace. This efficiency is in inverse proportion to the breakage, for, other conditions being equal, the amount of carbon absorbed by the hot CO_2 of the gases is in proportion to the surface exposed. This means that, other things being equal, the fuel consumption in a blast furnace per ton of pig iron produced is directly proportional to the breakage the coke receives between the oven and the hearth of the furnace. Therefore, in laying out new works it is of the utmost importance to have the blast furnaces and coke ovens studied together from this standpoint, in order to put the coke into the furnaces with the minimum amount of handling. This amount may be reduced with the right design to only two drops.

In recapitulation, this experience demonstrates that greater care is needed to distribute well an ore that is all lumps, particularly when smelted with soft coke that is subjected to the abuse of the repeated handlings incident to the modern filling and charging device. Whether the labor saved by such filling arrangements compensates for the loss due to impaired efficiency of the fuel resulting from such abuse, is a question left for others to solve.

*Patents pending.

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